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REVIEW COMMENT RECORD (RCR)

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Feb. 5, 1997

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W-058

4. Page
1 of 1

5. Document Number(s)/Title(s)

N/A /Replacement of the Cross-Site Transfer System (RCSTS)

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7. Reviewer

Omar Jaka

8. Organization/Group

TWRS-NS

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Author/Originator

Janet S. Davis
Author/Originator

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
1.	In Introduction (Page 1) should state that there will be no separate FSAR for RCSTS hence Authorization Basis for Tank Farm will be amended.	OJ	Change made.	
2.	After Tank Farm Authorization basis amendment package is approved by DOE-RL what will happen to PSAR for RCSTS ?	OJ	The following sentence was added to paragraph 1 of the Introduction: "The PSAR will not be a part of the authorization basis, but will remain as a reference document."	
3.	There are SARs for existing Cross-Site Transfer System in place. Are they going to be superseded or cancelled ?	OJ	It is our understanding that SARs for existing transfer systems will be superseded by the BIO and the FSAR.	
4.	On page 5 last paragraph, last two lines state that USQ documents are being performed against the current IOSRs. Instead it should say USQ is being done against ISB and IOSR.	OJ	Change made.	

Replacement of the Cross-Site Transfer System, Project W-058, Authorization Basis Amendment Task Plan

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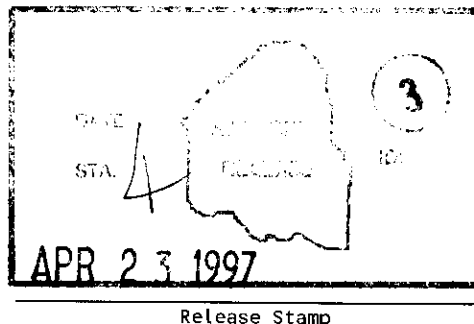
Abstract: This document provides the plan for the authorization basis amendment for the Replacement of the Cross-site Transfer System (RCSTS). The RCSTS will replace the present system with a buried pipe-in-pipe system.

This task plan document may be revised as more information is developed.

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1.0 INTRODUCTION

The Replacement of the Cross-site Transfer System (RCSTS, Project W-058) requires an authorization basis amendment package to be approved by U.S. Department of Energy, Richland Operations Office (RL). The RCSTS, which spans approximately 6.5 miles between the 200 East and 200 West areas, connects to the current tank farm facilities at the SY Tank Farm and the 244-A Lift Station. A Preliminary Safety Analysis Report (PSAR, Kidder 1996) addressed the entire cross-site system. Since tie-ins to the existing facility constitute a change to the current Tank Farms authorization basis, further analyses will be required to document the system in accordance with the Safety Management System process (WHC 1996a). These analyses will be documented in an amendment to the current authorization basis for the tank farms; an FSAR for W-058 will not be prepared. The PSAR will not be a part of the authorization basis, but will remain as a reference document.

The authorization basis amendment process for the RCSTS was initiated with Unreviewed Safety Question (USQ) evaluations, several of which have been or are being performed for the RCSTS. The USQ evaluations are being performed against the in-place Tank Farms Interim Safety Basis (ISB, WHC 1993) and Interim Operational Safety Requirements (IOSRs, Heubach 1996 and Lentsch 1996), with consideration given to assumptions and requirements in the draft Tank Farms Basis for Interim Operation (BIO, LMHC 1996a) and associated Technical Safety Requirements (TSRs, LMHC 1996b). The authorization basis amendment package will be prepared against the BIO and associated TSRs, both of which are assumed to be in place when the RCSTS authorization basis amendment will be submitted for approval.

SAIC has already performed part of what is needed to complete the RCSTS authorization basis amendment process by reviewing past analyses associated with cross-site transfers. This work was performed under contract MW6-SWV-168681. The following documents were reviewed for bases (assumptions, analysis methods, etc.) and applicable analyses:

- a. WHC-SD-WM-PSAR-001, Revision 1, *Replacement of the Cross-Site Transfer System Preliminary Safety Analysis Report* (Kidder 1996).
- b. WHC-SD-WM-BIO-001, Revision 0, *Tank Waste Remediation System Basis for Interim Operations* (LMHC 1996a).
- c. WHC-SD-WM-TSR-006, Revision E, *Tank Waste Remediation System Technical Safety Requirements* (associated with the BIO, LMHC 1996b).
- d. Flush system documentation (including WHC 1996d).

SAIC used the information gathered from this review to determine new analyses that will be required and a partial path forward. The results of these reviews are documented in a letter from SAIC to NHC (Young 1996). In summary, the conclusions were that the following analytical activities must be performed:

- a. Revision of the HAZOP to reflect the "as built" configuration and the new flush system,
- b. Reanalysis of the leak accidents using BIO assumptions and RCSTS design and operational parameters,
- c. Re-evaluation and reclassification of safety SSCs and TSRs based on the revised accident analysis results, and
- d. Incorporation of the revised HAZOP and control identification results in the hazard analysis database.

Those events identified for RCSTS that are adequately covered in the BIO will not be re-analyzed, but the adequacy of coverage of these events in the BIO will be discussed in the safety analysis document. Those accidents analyzed in the BIO that are similar but do not have the same bases (e.g., source term, tank waste inventories, or chi/Q values), will be updated in the safety analysis document to be included in the authorization basis amendment package.

This task plan document will be revised as more information is developed.

2.0 PURPOSE AND SCOPE

2.1 Purpose

This document provides the plan for the authorization basis amendment for the RCSTS. The RCSTS will replace the present system with a buried pipe-in-pipe system approximately 10.5 km (6.5 miles) long. The RCSTS will connect the 241-SY-A and 241-SY-B valve pits in the Hanford Site 200 West Area with the 244-A Lift Station in the 200 East Area. Transfer of liquid waste in either direction between the 200 East and 200 West Areas through one of two RCSTS lines, using existing tank farm transfer pumps, will be possible. Transfer of wastes from the 200 West Area to the 200 East Area, using existing tank farm transfer pumps and an RCSTS booster pump (Kidder 1996) will also be possible.

2.2 Scope of Authorization Basis Amendment

The RCSTS authorization basis update encompasses the following equipment:

- The cross-site transfer lines and associated equipment (pumps, valves, markers, etc.) between Valve Pits 241-SY-A and -B, in the 200 West area, and the 244-A Lift Station in the 200 East Area.
- The flush system as described in drawing H-2-822409 (WHC 1996d).
- Affected tank farm equipment (i.e., tie-in equipment and affected downstream equipment).

The following subjects are not addressed in the authorization basis update:

- Decontamination and decommissioning of the RCSTS. This aspect of the authorization basis is being deferred to the TWRS facility decontamination and decommissioning effort under the scope of the BIO/FSAR work.
- Impact of construction of the RCSTS on the existing facility. Construction of the RCSTS has been determined in USQ documents TF-96-0680, TF-96-0794, and TF-97-0020 to have no impact on the existing authorization basis.
- Individual waste transfers. Each transfer will require its own waste compatibility study and characterization to verify that transferred waste is within the inventory assumptions in the authorization basis amendment package. (It should be noted that the analysis for the RCTS conservatively assumes the maximum solid content that can be pumped in the lines and also assumes that the transferred material is aging waste, since it has the highest unit liter doses.)

It is assumed that the authorization basis documents in effect at the time of release of the project safety analysis document will be the BIO, TSRs associated with the BIO, the BIO Compliance Implementation Plan, the Flammable Gas JCO, and the DOE Safety Evaluation Report on the BIO. If the tank farms FSAR replaces the BIO prior to issuance of the RCSTS Authorization Basis Amendment package, this task plan will be changed accordingly and change requests for funding and schedule will be processed.

Changes to PHMC-prepared authorization basis documents resulting from the project safety analysis will be made by Engineering Change Notices. Any identified issues relating to the DOE-prepared SER will be communicated to DOE.

2.3 Safety Analysis Scope

Safety documentation in addition to that already reviewed by SAIC (e.g., the Flammable Gas JCO, Standing Order 97-01, USQ determinations, W-058 HAZOP-related documentation) will be reviewed to determine any further analyses or

documentation that might be required. Hazard analyses and accident analyses will be performed as necessary, and documented and reviewed in accordance with designated procedures.

3.0 TASK DESCRIPTION AND DELIVERABLES

3.1 DOE Orders, Standards and Procedures

The following DOE Orders and Standards apply to the Authorization Basis amendment process.

- DOE Order 5480.21, *Unreviewed Safety Questions*
- DOE Order 5480.22, *Technical Safety Requirements*
- DOE Order 5480.23, *Nuclear Safety Analysis Reports*
- DOE-STD-3011-94, *Guidance for Preparation of DOE 5480.22 (TSR) and 5480.23 (Safety Analysis Report) Implementation Plans*
- DOE-STD-3009-94, *Preparation Guide for U.S. DOE Nonreactor Nuclear Facility Safety Analysis Reports.*
- DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Facility Safety Analysis Reports.*
- DOE-STD-1104-96, *Review and Approval of Nonreactor Nuclear Facility Safety Analysis Reports.*

The following PHMC documents apply to the authorization basis amendment process:

- WHC-CM-4-46, *Safety Analysis Manual*
- WHC-CM-6-1, *Standard Engineering Practices*
- WHC-IP-0842, *TWRS Administration Manual*
 - Volume IV, Section 5.4, "Unreviewed Safety Questions"
 - Volume IV, Procedure 5.10, "Authorization Basis Amendments and Annual Updates"
- WHC-SD-MP-S/RID-001, *High Level Waste Storage Tank Farms / 242-A Evaporator Standards/Requirements Identification Document (S/RID), Rev. 1-B.*
- WHC-SD-MP-S/RID-002, *Westinghouse Hanford Company Site S/RID*

In addition, the following procedures (excerpted from the former WHC Safety Analysis and Nuclear Engineering Work Procedures manual WHC-CM-6-32) apply and are provided as appendices:

- WP-4.6, "Hazards Analysis" (Appendix A)
- WP-5.13, "Release Quantity" (Appendix B)
- WP-5.14, "Calculation of Airborne Release Consequences for Radiological and Toxic Materials" (Appendix C)
- WP-6.2, "Technical Peer Reviews and Hanford Environmental Dose Overview Panel Reviews" (Appendix D)

3.2 Guidance for Development and Documentation of Safety Analysis Assumptions and Parameters

DOE Order 5480.23 requires that the assumptions used in the analysis be stated. Assumptions will be stated where they occur in the body of the report and in a compilation of the assumptions in an appendix. Assumptions will be stated in sufficient detail that a reasonably qualified reader could follow the analysis logic without use of references.

Assumptions used in the analyses will be consistent with those in the BIO. The following assumptions are already defined. Others will be defined based on review of the BIO and other documents (see Section 2.3).

- Maximum offsite individual consequence calculations
 - Meteorology and receptor location -worst case chi/Q value at a distance and direction of 8760 m N [near bank of the Columbia River, consistent with the BIO and WHC-SD-WM-SARR-016, Revision 2 (Van Keuren 1996a)]
- Risk Evaluation guidelines as described in WHC-CM-4-46 (WHC 1996b), Section 7.0 (those used for the BIO)
 - Revision 1 for radiological risk evaluation guidelines
 - Revision 4 for toxicological risk evaluation guidelines
- Facility Description
 - Will include the RCSTS, flush system, and affected tank farm equipment (i.e., tie-in equipment and affected downstream equipment).
 - Tank waste compositions will be based on waste compositions defined in WHC-SD-WM-SARR-016, Revision 2 (Van Keuren 1996a) and WHC-SD-WM-SARR-011, Revision 2 (Van Keuren 1996b).
 - Will include nonwaste hazardous material inventories (e.g., bulk chemicals used for adjusting Ph)

3.3 Task and Deliverable Descriptions

The major tasks for the RCSTS authorization basis amendment are listed below. See Table 4.0-1 for a more detailed list of tasks and responsible personnel, including reviews and comment resolution.

Task 1 - Oversee Scope, Cost and Schedule

The primary responsibility for oversight of the cost and schedule associated with preparation, completion and implementation of this Authorization Basis Amendment lies with the Project Engineer.

Task 2 - Complete USQD #TF-96-1007 and USQD #TF-96-1008

USQD #TF-96-1007, "Replacement Cross-site Transfer System Tie-ins at 244-A Lift Station and 241-SY Valve Pits" (a USQ evaluation of RCSTS

operation), and USQD #TF-96-1008, "Flush System for the Replacement Cross-site Transfer System," will be completed. The USQ evaluations must consider Standing Order 97-01 (LMHC 1997) as being part of the current authorization basis.

This task plan assumes the in-progress USQ evaluations, when finalized, will have conclusions consistent with the preliminary results. If the conclusions change, this task plan will be revised accordingly.

Background on RCSTS USQ Evaluations and Preliminary Results of In-Progress Evaluations

The Replacement Cross-site Transfer System is a modification to the tank farms with tie-ins at both ends to the existing facilities of the SY Tank Farms and 244-A Lift Station. To address this modification during both operation and construction, several USQ evaluations were performed and two others are in progress. The USQ evaluations are being performed against the ISB and the current IOSRs (Heubach 1996 and Lentsch 1996) rather than the BIO and its associated TSRs. However, compatibility between the USQs and the BIO/TSRs will be established in Task 4. The USQ documents and the results of each are summarized in Table 3.3.1-1.

Table 3.3.1-1 - USQ Determinations for Project W-058

USQD #	Title	Type	Determination	Status
TF-96-0680	Perform Construction Activities Associated with Replacement of Cross-site Transfer Line within SY Farm.	Screening	No USQ exists	Completed
TF-96-0794	Install Nozzles for Replacement Cross-site Lines at 244-A Lift Station	Screening	No USQ exists	Completed
TF-96-1007	Replacement Cross-site Transfer System Tie-ins at 244-A Lift Station and 241-SY Valve Pits (addresses operation of RCSTS)	Evaluation	Preliminary results: USQ may exist	In progress
TF-96-1008	Flush System for the Replacement Cross-site Transfer System	Screening	Preliminary results: USQ may exist	In progress
TF-97-0020	Construct the Flush System In and Around SY Farm to Support the Replacement Cross Site Transfer Project	Screening	No USQ exists	Completed

Preliminary results of the flush system USQ evaluation (TF-96-1008) indicate that the flush system is within the current authorization basis because it is a water service system. [The current authorization basis (i.e., ISB) does not address water service systems as being equipment important to safety.] However, the BIO requires safety-significant backflow preventers on water service systems. The fact that the flush system does not have a backflow preventer needs to be addressed and resolved.

Preliminary results of the USQ evaluation addressing operation of the RCSTS (TF-96-1007) indicate that tie-ins and operation of the RCSTS may not be covered by the current authorization basis. The resulting issues to be addressed in the safety analysis include:

- 1) Potential increased frequency of analyzed accidents,
- 2) Potential increased consequences of analyzed accidents,

- 3) Potential increased frequency of previously evaluated equipment malfunction,
- 4) Potential increase in consequences of previously evaluated equipment malfunctions, and
- 5) The need for new or revised TSRs.

Task 3 - Prepare, Review and Revise Task Plan

This task plan was prepared to document expectations for deliverables, responsibilities, and schedule. All PHMC subcontractor and sub-subcontractor participants in the plan (not including certain LMHC and FDH managers and RL) will review the plan for acceptability.

Task 4 - Review Additional Safety Documentation and Specific BIO Scenarios

The following documents will be reviewed to identify any additional analyses that might be required, and to determine a path forward for the final analysis document:

- a. USQD #TF-96-1007, "Replacement Cross-site Transfer System Tie-ins at 244-A Lift Station and 241-SY Valve Pits" (USQ evaluating RCSTS operation)
- b. USQD #TF-96-1008, "Flush System for the Replacement Cross-site Transfer System"
- c. WHC-SD-WM-JCO-007, Revision 1, *Flammable Gas Unreviewed Safety Question: Justification for Continued Operation* (WHC 1997)
- d. Standing Order 97-01 (LMHC 1997)
- e. Letter, J. Young (SAIC) to J.L. Gilbert (NHC), "Technical Path Forward Report for Incorporation of the RCSTS into the TWRS Authorization Basis (BIO), Contract MW6-SWV-168681, Task Order 38," (Young 1996).

The deliverables resulting from review of these documents will be:

- a. Identification of any additional analyses that are required
- b. Definition of a path forward for the final analyses
- c. Discussion of disposition of PSAR accidents for flammable gas deflagration in the RCSTS lines
- d. Determination of compatibility between the USQs and the BIO/TSRs, and definition of a path forward if necessary.

In addition, 3 specific BIO scenarios must be reviewed for applicability to RCSTS, with documentation explaining why each is applicable or not

applicable to RCSTS, and how to resolve those that are not applicable. The 3 BIO scenarios are:

- a. Caustic spray leak
- b. Mixing of incompatible material - toxic vapor generation
- c. Mixing of incompatible material - tank pressurization

Task 5 - Review and Update HAZOP Analyses and Documentation

The following documents will be reviewed and revised as discussed below:

- a. WHC-SD-W058-PHA-001, Rev. 1 (Siemer 1995), "Hazards and Operability Study for the Replacement Cross-Transfer System," will be revised by adding an appendix that (1) addresses new hazardous conditions (such as those associated with the flush/caustic addition system) and (2) lists hazardous conditions that are no longer pertinent (such as those associated with risers).
- b. The BIO datafile will be revised according to the HAZOP findings. The W-058 hazards applied in the BIO in the evaluation of the existing cross-site transfer system will remain as such. All of the W-058 hazards will be added to the datafile, even if they are duplicates of the hazards applied to the existing cross-site transfer system. (A designator system will be developed to distinguish between W-058 hazards applied to the existing transfer system and W-058 hazards applied to W-058.)
- c. WHC-SD-WM-TI-773, Rev. 0 (Niemi 1996), "Hazard Analysis Results Report," will be revised.

The HAZOP evaluations will be performed in accordance with Appendix A of this task plan. The results of the HAZOP, including identification of new scenarios to be further analyzed (if any), will be documented in the W-058 Authorization Basis Amendment safety analysis document.

The following documents will not be revised in this effort:

- o FSAR HAZOP datafile
- o WHC-SD-WM-TI-764 ("Hazard Analysis Database Report" which documents the FSAR datafile)
- o WHC-SD-WM-TI-759 ("Hazard Evaluations for the Tank Waste Remediation System Final Safety Analysis Report")

Task 6 - Perform and Document Accident Analyses

The frequency and consequences of the scenarios designated for further analysis in Task 5 will be determined. The consequence analyses will be performed in accordance with Appendices B and C of this task plan.

The scenarios that must be analyzed to reflect the BIO assumptions and RCSTS design and operational parameters are as follows, not including those additional scenarios that may be identified in Task 5 (Young 1996):

- a. Subsurface leak remaining subsurface
- b. Surface leak resulting in pool
- c. Subsurface leak resulting in pool
- d. Spray leak in structure or from overground waste transfer lines
- e. Spray leak from underground transfer line

Other potential scenarios that might require analysis, depending on the results of Task 5, are:

- a. Caustic spray leak
- b. Mixing of incompatible material - toxic vapor generation
- c. Mixing of incompatible material - tank pressurization

Task 7 - Identify TSRs and SSCs

Based on the results of Task 6, identify and document:

- a. New and/or revised controls and compensatory measures, if necessary, as determined by "control identification meetings", and
- b. New and/or revised SSC designations, if necessary.

Task 8 - Prepare Final Safety Analysis Document as an SARR

The results from Tasks 2 - 7 will be used to prepare the authorization basis amendment safety analysis document. The safety analysis will be documented in accordance with WHC-CM-4-46 (WHC 1996d), including radiological risk evaluation guidelines from Revision 1 of Section 7.0, and toxicological risk evaluation guidelines from Revision 4 of Section 7.0; WHC-IP-0842, Vol. IV, Section 5.10 (WHC 1996a); and DOE-STD-3009-94.

Flammable gas concerns will be addressed with respect to the Flammable Gas Justification for Continued Operation (JCO, WHC 1997) and Standing Order 97-01 (LMHC 1997). The fact that the flush system does not have safety-significant backflow preventers (while the BIO requires service water systems to have these), will be addressed and resolved.

The safety analysis will be documented as a safety analysis reference report (SARR) that follows the format and content guidance in Attachment D of WHC-IP-0842, Volume IV, Procedure 5.10, and includes:

- Documentation of all assumptions made
- Additional analyses
- Responses to the W-058 PSAR SER
- Resolutions to open items in the PSAR
- Resolutions to issues identified in USQDs:
 - Potential increased frequency of analyzed accidents,
 - Potential increased consequences of analyzed accidents,
 - Potential increased frequency of previously evaluated equipment malfunction,
 - Potential increase in consequences of previously evaluated equipment malfunctions, and
 - The need for new or revised TSRs
- New or revised SSC designations
- TSR derivations, and compensatory measures if needed
- A table mapping the document sections to those in the BIO

Task 9 - Technical Peer Review and HEDOP Review of Safety Analysis Document and Resolution of Comments

Technical peer reviews in subtasks 9a, 9b, and 9c and HEDOP reviews will be performed in accordance with Appendix D of this task plan. See Table 4.0-1 for a list of subject areas that must be addressed in the reviews. The person designated for each area of expertise must also review the appropriateness of TSR derivation and SSC designations related to the assigned area of expertise.

Task 10 - Mark up TSRs and Prepare ECN

The TSR documentation resulting from Task 7 will be used to mark up the TSR document and prepare ECN page changes. A table will be prepared to summarize the changes in the TSRs (i.e., a table that lists the existing controls that are being changed, and how they are being changed). This table will be used in the S/RID evaluation and as needed for presentations to LMHC, FDH and RL.

Task 11 - Mark Up BIO and Prepare ECN

The safety analysis documented and reviewed in tasks 8 and 9 will be used to mark up the BIO and prepare ECN page changes. A table will be prepared to summarize the changes in the BIO (i.e., a table listing the existing parameters that are being changed, how they are being changed, and the effect of the change). This table will be used in the S/RID evaluation and as needed for presentations to LMHC, FDH, and RL.

Task 12 - Revise S/RID if Necessary

Based on the results of the safety analysis documented and reviewed in Tasks 8 and 9, and the tables summarizing the TSR and BIO changes from Tasks 10 and 11, the need for revising the S/RID will be evaluated. If a revision is necessary, an ECN and corresponding page changes will be prepared.

Task 13 - Develop Amendment Implementation Plan

Based on the results of the safety analysis documented and reviewed in Tasks 8 and 9, an Amendment Implementation Plan will be developed.

This document will describe all necessary actions to completely implement the authorization basis amendment (e.g., implementation of compensatory measures, implementation of new or revised TSRs, changes to the authorization basis document list, changes to the Facility Compliance Matrix, changes to procedures, training associated with implementation of new controls and procedures, etc.) The document will also consider potential changes to the in-place Compliance Implementation Plan.

The Amendment Implementation Plan will be prepared in accordance with Attachment F of WHC-IP-0842, Vol. IV, Section 5.10 (WHC 1996a), based on the results of the all previous tasks. The plan will include a schedule and responsibilities for completion of implementation and the criteria to be used for verification of full implementation.

Task 14 - Assemble Authorization Basis Amendment Package

The Authorization Basis Amendment Package will contain:

Authorization basis documents:

- Markup of BIO (and/or page changes) and ECN.
- Markup of BIO TSRs (and/or page changes) and ECN.

Supporting references:

- All RCSTS-related USQ documentation.
- Safety Analysis Document (including documentation of Technical Peer Reviews and HEDOP review, and EDT).

Implementation documents:

- Compensatory measures, if applicable.
- Amendment Implementation Plan (which will include any considerations for the in-place Compliance Implementation Plan).

- Markup of S/RID and corresponding ECN (if applicable).

Note that revised tank waste inventory documents are not required as part of the authorization basis amendment package because existing waste tank inventory information in WHC-SD-WM-SARR-011, Rev. 2 (Van Keuren 1996b), and WHC-SD-WM-SARR-016, Rev. 2 (Van Keuren 1996a), will be used as the basis for analyzing bounding consequences.

Task 15 - LMHC and External Review of Authorization Basis Amendment Package and Resolution of Comments

Functional reviews of the amendment package will be performed in those areas of expertise identified in Task 15 in Table 4.0-1. Operations & Projects Safety Support will "shepherd" the document through these reviews.

Task 16 - Submit Authorization Basis Amendment Package to FDH and Facilitate Transmittal to RL

Operations & Projects Safety Support will prepare the authorization basis amendment package transmittal letter to FDH. The package will be transmitted to A. M. Umek (Director, TWRS Project - FDH) with copy coverage to C.L. Whalen (Manager, ES&H Work Controls - FDH) from L.E. Hall (Manager, Lockheed Martin Hanford Company). The letter will include specific requests for FDH to communicate to RL (a) that a Safety Evaluation Report (SER) is needed to allow completion and implementation of the authorization basis amendment, (b) when the SER is needed and why, (c) a PHMC single point of contact for comments and communications from RL, and (d) a request for comments to be submitted on a Review Comment Record (RCR) form. The letter should also request that the SER be issued only after comments have been resolved (i.e., comments should not be provided in the SER).

FDH will review the package and comments will be resolved accordingly. When comments are resolved, FDH will submit the Authorization Basis Amendment Package to RL.

Task 17 - RL Review and Approval of Authorization Basis Amendment Package

RL will review the package. Comments will be resolved accordingly, and RL will issue the SER.

Task 18 - Issue Revised Safety Documentation

The as-approved versions of the following safety documentation will be formally issued in accordance with appropriate document control procedures and WHC-IP-0842, Volume IV, Procedure 5.10 (WHC 1996a):

- a. Revised BIO (via ECN)
- b. Revised BIO TSRs (via ECN)

- c. Safety Analysis Document
- d. Safety Basis and/or Authorization Basis Document Lists
- e. Amendment Implementation Plan
- f. Procedures

Task 19 - Complete All Action Items, Verify Implementation, and Notify RL

All action items from the Amendment Implementation Plan will be completed and verified. A letter will be prepared to notify FDH of full implementation. The letter will be from L. E. Hall (President and General Manager - LMHC) to A. M. Umek (Director, TWRS Project - FDH), with copy coverage to C.E. Whalen (Manager, ES&H Work Controls - FDH). The letter will request FDH to notify RL of full implementation of the Authorization Basis Amendment. FDH will then notify RL accordingly.

4.0 RESPONSIBILITIES AND MANPOWER REQUIREMENTS

See Table 4.0-1.

Table 4.0-1. Responsibilities and Manpower Requirements for RCSTS Authorization Basis Amendment

NOTES:

1. "NA" means "not applicable," either because (a) the task entry is a merely a title for a group of subtasks, or (b) the man-day entry is covered by funding from a source other than that for this authorization basis amendment task.
2. Acronyms for groups in the TWRS Nuclear Safety & Licensing organization:
 OPSS = Operations & Projects Safety Support
 ABMI = Authorization Basis Management & Implementation

TASK / DELIVERABLES	ROLE	RESPONSIBILITY	DURATION (Workdays)	MAN- DAYS
1. Oversee cost and schedule of AB amendment	Project Engineer	J.L. Gilbert (NHC)	Entire	NA
2. Complete USQD #TF-96-1007 and #TF-96-1008	USQ Evaluator	W.L. Cowley (DESH)	15	5
	USQ Evaluator	W.L. Cowley (DESH)	15	5
3. Prepare, review and revise Task Plan	NA	NA	NA	NA
3a. Prepare and coordinate review of task plan	OPSS Rep	J.S. Davis (DESH)	10	5
	OPSS Licensing Engineer	T.G. Goetz (DESH)		2
3b. Review Task Plan	All participants (not including certain LMHC and FDH managers and RL)	[Those listed in this plan]	3	0.25 ea.

TASK / DELIVERABLES	ROLE	RESPONSIBILITY	DURATION (Workdays)	MAN- DAYS
3c. Revise Task Plan according to reviews and issue as SD	OPSS Licensing Engineer	T.G. Goetz (DESH)	10	1
4. Review additional safety documentation and specific BIO scenarios	NA	NA	NA	NA
4a. Review: <ul style="list-style-type: none"> o USQDs #TF-96-1007, #TF-96-1008, #TF-97-0020 o Flammable Gas JCO o Standing Order 97-01 o SAIC Report (Young 1996) Deliverables: <ul style="list-style-type: none"> o Identify any additional required analyses o Define path forward for final analyses o Discussion of disposition of PSAR accidents for flammable gas deflagration in the RCSTS lines o Define path forward to resolve any identified incompatibilities between the USQs and the BIO/TSRs 	Safety Analyst	R.J. Kidder (FDNW)	10	5
	Consultant	J. Young (MSI)	10	5

TASK / DELIVERABLES	ROLE	RESPONSIBILITY	DURATION (Workdays)	MAN- DAYS
4b. Review 3 BIO accidents for applicability to RCSTS: <ul style="list-style-type: none"> o Caustic spray leak o Mixing of incompatible material - toxic vapor generation o Mixing of incompatible material - tank pressurization Deliverable: Documentation explaining why each BIO analysis is applicable or not applicable to RCSTS, and how to resolve those that are not applicable	Consultant	J. Young (MSI)	5	2
5. Review and update HAZOP analyses and documentation	NA	NA	NA	NA
5a. Review: <ul style="list-style-type: none"> o BIO HAZOP datafile o WHC-SD-W058-PHA-001 o WHC-SD-WM-TI-773 (BIO HAZOP results) To determine: <ul style="list-style-type: none"> o Additional required analyses o Path forward for final analyses 	Hazard Analyst	D.J. Braun (FDNW)	5	1
	Consultant	R. Slagle (SAIC)	5	1
5b. Update BIO HAZOP documentation and designate scenarios for consequence analysis	Hazard Analyst	D.J. Braun (FDNW)	50	30
	Consultant	R. Slagle (SAIC)	30	10
6. Perform and document accident analyses	NA	NA	NA	NA

TASK / DELIVERABLES	ROLE	RESPONSIBILITY	DURATION (Workdays)	MAN- DAYS
6a. Determine frequency of designated scenarios and document logic	Consequence Analyst	J.C. Van Keuren (FDNW)	5	1
6b. Perform and document consequence analyses for designated scenarios	Consequence Analyst	J.C. Van Keuren (FDNW)	35	25
7. Identify TSRs and SSCs	NA	NA	NA	NA
7a. Identify and document new and/or revised controls and compensatory measures, if necessary, based on results of Task 6.	ABMI Rep	M.S. Twiselton (DESH subcontractor)	TBD	TBD
	Others as needed	TBD	TBD	TBD
7b. Identify and document new and/or revised SSCs designations, if necessary, based on results of Task 6.	Design Authority	R.L. Schlosser (LMHC)	5	2
8. Prepare final safety analysis document as an SARR, based on results of all previous tasks	Safety Analyst	R.J. Kidder (FDNW)	30	20
9. Technical peer review and HEDOP review of safety analysis document (including appropriateness of TSR derivation and SSC designations related to each topic area) and resolution of comments. Topic areas:	OPSS Licensing Engineer (coordination and overall review)	T.G. Goetz (DESH)	20	20
	Hazard Analyst	J.E. Kelly (FDNW)		5
	Hazard Analyst	J.E. Kelly (FDNW)		1

TASK / DELIVERABLES	ROLE	RESPONSIBILITY	DURATION (Workdays)	MAN- DAYS
9c. Consequence analyses	Consequence Analyst	D.A. Himes (FDNW)		5
9d. Criticality discussions	Criticality Analyst	T.S. Vail (DESH)		3
9e. Seismic discussions, if needed	Seismic Analyst	TBD		3
9f. Flammable gas discussions, if needed	Flammable Gas Analyst	J.M. Grigsby (G&PC)		4
9g. Facility description and design specifications relating to TWRS West Area (SY-A and -B Valve Pits and down/up stream)	WTF Rep	D.R. Nunamaker (LMHC)		4
9h. Facility description and design specifications relating to TWRS East Area (244-A Lift Station and downstream)	ETF Rep	G.N. Hanson (LMHC)		4
9i. RCSTS description and design specifications	Project Engineer	J.L. Gilbert (NHC)		NA
9j. Consistency of consequence calculations with Hanford site recommendations	HEDOP Reviewer	D.A. Himes (FDNW)		0.5
9k. Resolve comments on safety analysis document and TSRs and prepare EDT (include documentation of peer review approvals in safety analysis and controls documents)	Safety Analyst	R.J. Kidder (FDNW)	10	20
	Other analysts as needed	TBD		TBD

TASK / DELIVERABLES	ROLE	RESPONSIBILITY	DURATION (Workdays)	MAN- DAYS
10. Mark up TSRs, prepare ECN, and prepare table summarizing changes	ABMI Rep	M.S. Twiselton (DESH subcontractor)	15	10
11. Mark up BIO, prepare ECN, and prepare table summarizing changes	OPSS Licensing Engineer	T.G. Goetz (DESH)	10	10
12. Evaluate need for revising S/RID and make necessary ECN and S/RID page changes (if any).	S/RID Expert/Coordinator	E. Biebesheimer (LMHC)	10	8
	S/RID Subject Area Expert	TBD	5	3
	S/RID Subject Area Expert	TBD	5	3
	S/RID Subject Area Expert	TBD	5	3
	S/RID Subject Area Expert	TBD	5	3
	S/RID Subject Area Expert	TBD	5	3
13. Develop amendment implementation plan (including consideration of potential changes to CIP)	ABMI Rep	M.S. Twiselton (DESH subcontractor)	10	5
14. Assemble AB Amendment Package	OPSS Licensing Engineer	T.G. Goetz (DESH)	5	5

TASK / DELIVERABLES	ROLE	RESPONSIBILITY	DURATION (Workdays)	MAN- DAYS
15. MILESTONE LMHC and external review of AB Amendment Package and resolution of comments. Verify:	OPSS Licensing Engineer (coordination and overall review in accordance with Att. E of WHC-IP-0842, Vol. IV, Proc. 5.10)	T.G. Goetz (DESH)	20	10
15a. that (a) package is based on appropriate design information and (b) SC and SS SSCs have been appropriately designated	Design Authority Lead	R.L. Schlosser (LMHC)		4
15b. RCSTS description and design specifications	Project Lead	G.L. Parsons (NHC)		NA
15c. that all nuclear safety issues have been addressed adequately	Nuclear Safety	O.M. Jaka (LMHC)		3
15d. that all QA issues have been addressed adequately	QA	T.L. Bennington (LMHC)		3
15e. that all environmental issues have been addressed adequately (review required by WHC-CM-7-5, Section 13.0, p. 10)	Environmental Compliance Officer	R.K. P'Pool (LMHC)		3
15f. package is appropriate for transmittal to FDH and RL	OPSS Manager	C.E. Leach (DESH)		2

TASK / DELIVERABLES	ROLE	RESPONSIBILITY	DURATION (Workdays)	MAN- DAYS
15g. appropriate controls have been included and that implementation plan addresses all necessary actions (per Att. F of WHC-IP-0842, Vol IV, 5.10)	ABMI	J.G. Propson (DESH)		2
15h. accuracy of facility and operations descriptions and implementability of controls	ETF Ops Manager	W.E. Ross (LMHC)		NA
15i. accuracy of facility and operations descriptions and implementability of controls	WTF Ops Manager	J.G. Burton (LMHC)		NA
15j. Resolve LMHC and external review comments	OPSS Licensing Engineer	T.G. Goetz (DESH)	10	5
	Safety Analyst	R.J. Kidder (FDNW)		5
	Others as necessary	TBD		TBD
16. Submit AB Amendment Package to FDH and facilitate transmittal to RL.	NA	NA	NA	NA
16a. Prepare letter for submittal of AB Amendment Package to FDH	OPSS Licensing Engineer	T.G. Goetz (DESH)	1	0.25
	LMHC Manager	L.E. Hall (LMHC)		NA
16b. Facilitate, as needed, transmittal of package to RL through FDH	LMHC Manager	L.E. Hall (LMHC)	5	NA

TASK / DELIVERABLES	ROLE	RESPONSIBILITY	DURATION (Workdays)	MAN- DAYS
16c. FDH review of AB Amendment Package	TWRS Project Rep	B.K. Hampton (FDH)	15	NA
	ES&H Work Controls Rep	C.L. Whalen (FDH)		5
	Others as designated by FDH	TBD		NA
16d. Resolve FDH comments	OPSS Licensing Engineer	T.G. Goetz (DESH)	5	5
	Safety Analyst	R.J. Kidder (FDNW)		2
	Others as necessary	TBD		TBD
16e. MILESTONE FDH submit AB Amendment Package to RL	TWRS Project Rep (FDH)	B.K. Hampton (FDH)	3	NA

TASK / DELIVERABLES	ROLE	RESPONSIBILITY	DURATION (Workdays)	MAN- DAYS
17. DOE review and approval of AB Amendment Package	NA	NA	NA	NA
17a. DOE review of AB Amendment Package (Tier II) including comment resolution & rereview	RL Project Reps	B.J. Harp (RL)	45	NA
		S.A. Wiegman (RL)		NA
17a.1. Resolve DOE Tier II comments	OPSS Licensing Engineer	T.G. Goetz (DESH)	15	12
	Safety Analyst	R.J. Kidder (FDNW)		12
	Others as necessary	TBD		TBD
17b. DOE review of AB Amendment Package (Tier III) including comment resolution & rereview	RL ES&H Rep	M. Jackson (RL)	25	NA
17b.1. Resolve DOE Tier III Comments	OPSS Licensing Engineer	T.G. Goetz (DESH)	10	10
	Safety Analyst	R.J. Kidder (FDNW)		10
	Others as necessary	TBD		TBD
17c. DOE issue SER	Director, RL TWR	J. D. Wagoner (RL)	8	NA

TASK / DELIVERABLES	ROLE	RESPONSIBILITY	DURATION (Workdays)	MAN- DAYS
18. Issue revised safety documentation	NA	NA	NA	NA
18a. Issue Safety Analysis Document	OPSS Licensing Engineer	T.G. Goetz (DESH)	5	1
18b. Issue revised BIO (via ECN)	OPSS Licensing Engineer	T.G. Goetz (DESH)	5	1
18c. Issue revised BIO TSRs (via ECN)	ABMI Rep	M.S. Twiselton	5	1
18d. Revise safety basis and/or AB document lists	OPSS Licensing Engineer	T.G. Goetz (DESH)	5	1
18e. Finalize Amendment Implementation Plan per DOE SER	ABMI Rep	M.S. Twiselton (DESH subcontractor)	5	1
18f. Procedure rewrite	ABMI	M.S. Twiselton (DESH subcontractor)	30	20
19. Complete all action items, verify implementation, and notify RL	NA	NA	NA	NA

TASK / DELIVERABLES	ROLE	RESPONSIBILITY	DURATION (Workdays)	MAN- DAYS
19a. TBD action items from implementation plan	TBD	TBD	TBD	TBD
19b. Verify full implementation	Facility Manager	M.P. Delozier (LMHC)	10	NA
	Facility Manager Reps as needed	TBD		2 ea.
19c. Prepare letter to notify FDH of full implementation	Operations Rep	TBD	3	2
	LMHC Manager	L.E. Hall (LMHC)		NA
19d. FDH notify DOE of full implementation	FDH TWRS Project Manager	U.M. Umek (FDH)	5	NA

5.0 SCHEDULE

Table 5.0-1. Schedule for W-058 Authorization Basis Amendment

TASK NUMBER	TASK	SCHEDULE	DURATION
NA	Review safety analyses from PSAR o Identify additional required analyses o Define path forward for final analyses	Done	NA
1-7	Perform additional analyses	12/02/96 - 02/17/97	11 wks
8	Assemble final safety analysis document, including SSC designations and derivations of TSRs	12/23/97 - 03/31/97	14 wks
9 - 9j	Technical peer review and HEDOP review of final safety analysis document	03/31/97 - 04/11/97	2 wks
9k	Resolve comments from technical peer review and HEDOP review	04/14/97 - 04/25/97	2 wks
10	Prepare TSR document	04/14/97 - 05/02/97	3 wks
11-14	Prepare Authorization Basis Amendment Package	04/28/97 - 05/09/97	2 wks
15-15i	PHMC review of Authorization Basis Amendment Package	05/12/97 - 05/23/97	2 wks
15j-16	Resolve PHMC comments (MILESTONE) and issue Authorization Basis Amendment Package to DOE	05/26/97 - 06/06/97	2 wks
17a	DOE Tier II review of Authorization Basis Amendment Package (including comment resolution)	06/09/97 - 08/08/97	9 wks
17b	DOE Tier III review of Authorization Basis Amendment Package (including comment resolution)	08/11/97 - 09/12/97	5 wks
17c	DOE approval via SER	09/15/97 - 09/24/97	1.5 wks
18-19	Implementation	09/25/97 - 11/20/97	8 wks

6.0 TASK CONTROL

Initially, the task will be managed with bi-weekly meetings to status progress. The task will be re-evaluated at the end of the first deliverable for schedule and cost variances. Corrective actions will be taken and this task plan, at a minimum, will be revised to reflect any necessary changes. Scope changes will be handled by formal change control as required by the project and the TWRS authorization basis amendment procedure (WHC-IP-0842, Vol. IV, Procedure 5.10).

7.0 REFERENCES

DOE Order 5480.21, *Unreviewed Safety Questions*

DOE Order 5480.22, *Technical Safety Requirements*

DOE Order 5480.23, *Nuclear Safety Analysis Reports*

DOE-STD-3011-94, *Guidance for Preparation of DOE 5480.22 (TSR) and 5480.23 (Safety Analysis Report) Implementation Plans*

DOE-STD-3009-94, *Preparation Guide for U.S. DOE Nonreactor Nuclear Facility Safety Analysis Reports.*

DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Facility Safety Analysis Reports.*

DOE-STD-1104-96, *Review and Approval of Nonreactor Nuclear Facility Safety Analysis Reports.*

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Lentsch, J. W., 1996, *Single-Shell Tank Interim Operational Safety Requirements*, WHC-SD-WM-OSR-005, Revision 0E, Westinghouse Hanford Company, Richland, Washington.

Kidder, R. J., 1996, *Preliminary Safety Analysis Report for the Replacement of the Cross-site Transfer System*, WHC-SD-W058-PSAR-001, Revision 1. Westinghouse Hanford Company, Richland, Washington.

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LMHC, 1996b, *Draft Tank Waste Remediation System Technical Safety Requirements*, WHC-SD-WM-TSR-006, Revision E, October 1996, Lockheed Martin Hanford Company, Richland, Washington.

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Van Keuren, J. C., 1996b, and J. S. Davis, *Toxic Chemical Considerations for Tank Farm Releases*, WHC-SD-WM-SARR-011, Revision 2. Westinghouse Hanford Company, Richland, Washington.

WHC, 1996a, *TWRS Administration Manual*, WHC-IP-0842, Volume IV, Westinghouse Hanford Company, Richland, Washington.

- Section 5.4, "Unreviewed Safety Questions," Revision 9
- Section 5.10, "Authorization Basis Amendments and Annual Updates"

WHC, 1996b, *Safety Analysis Manual*, WHC-CM-4-46, Westinghouse Hanford Company, Richland, Washington.

WHC, 1996c, *Tank Waste Remediation System Interim Safety Basis*, WHC-SD-WM-ISB-001, Rev 0L, 1993, Westinghouse Hanford Company, Richland, Washington.

WHC, 1996d, *P&ID Water Flush System*, Drawing H-2-822409, Revision 0.

WHC, 1996e, WHC-CM-6-1, *Standard Engineering Practices*.

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APPENDIX A. PROCEDURE TO FOLLOW FOR HAZARD ANALYSIS

(Work Procedure WP-4.6, "Hazards Analysis," excerpted from the former WHC manual WHC-CM-6-32, *Safety Analysis and Nuclear Engineering Work Procedures*.)

40 pages

WESTINGHOUSE HANFORD COMPANY

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Safety Analysis and
Nuclear Engineering

HAZARDS ANALYSIS

Approved by

A. L. Ramble, Manager
Safety Analysis and Nuclear
Engineering

1.0 PURPOSE

The purpose of this procedure is to provide SA&NE with the requirements, responsibilities, methodology, and deliverables in performing hazards analyses (HA) at the Hanford Site. The HA provides an assessment of either facility or project hazards that can produce undesirable consequences for onsite workers, the public, and/or the environment.

The HA provides the data for follow-on activities, such as accident analysis, safety classifications, controls identification, and emergency preparedness.

2.0 SCOPE

The HA provides basic information used to develop safety documentation (e.g., basis for interim operation, safety analysis reports [SAR], technical safety requirements [TSR], emergency planning documents, and emergency action levels). The HA also provides information used in the emergency planning documents that provide emergency action levels, evacuation plans, etc. Any deviation from the basic requirements of this procedure will be identified in the appropriate planning document in accordance with WHC-CM-6-32, WP-4.1.

The scope of this procedure is consistent with the HA guidance provided in DOE-STD-3009-94, Chapter 3.0, and DOE-STD-3011-94, Appendix C.

3.0 DEFINITIONS

Accidents. An unplanned event or sequence of events that results in undesirable consequences.

Administrative Control (AC). A section of a Technical Safety Requirement that imposes administrative requirements necessary to ensure safe operation of the facility.

Adverse Consequences. Established guidelines for radiological and toxicological exposures have been exceeded.

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HAZARDS ANALYSIS

Boundary. The initial extent of an analysis. Boundaries define a system and the extent of its influence.

Configuration. The positions of valves, breakers, compositions, active safety interlocks, etc. System configurations can represent specifics including fluid flow, heat transfer or electrical power distribution.

Consequences. The result or effect of a release of hazardous material (radiological or chemical) usually expressed in terms of dose and exposure.

Controls. The facility's limits on operational conditions, safe boundaries, management and administrative requirements to ensure the safe operation of a nuclear facility.

Defense-In-Depth. An approach to safety that does not rely on any one layer of protection, no matter how good, to prevent or mitigate undesirable accident consequences.

Diagram-Driven HA Techniques. Use of diagrams or trees to graphically represent the interdependence of equipment and personnel in an evaluation. This can be the inductive or the deductive approach. Diagram-driven techniques include the event tree and the fault tree.

Failure. The condition that exists when a system or component cannot perform its intended function. Failure is often quantified to a system specification (e.g., a HEPA filter that is degraded to 90%).

Failure Modes and Effects Analysis (FMEA). A process that identifies single-failure modes that either directly result in or contribute significantly to an accident. The FMEA generate a qualitative, systematic reference list of equipment, failure modes, and effects.

Form-Driven HA Technique. Use of forms to ensure standardization and completeness in an evaluation, usually the inductive approach. Form-driven techniques include the FMEA, the Preliminary Hazards Assessment (PHA), and the Hazards and Operability Study (HAZOP).

Graded Approach. The justification for the level of analyses and thoroughness of documentation that constitutes a responsible effort in the sophistication of the hazard evaluations. This justification considers the magnitude of the hazards being addressed, the complexity of the facility and systems, and the specific approval being sought.

Hazard. A source of danger (material, energy source, or operation) with the potential to cause illness, injury, or death to personnel; or damage to a facility or to the environment.

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HAZARDS ANALYSIS

Hazards Analysis. A comprehensive assessment of facility or project hazards and/or accident scenarios that can produce undesirable consequences for the onsite population, public, and/or the environment.

Hazards Analysis Document (HAD). The formal documentation of the hazards of the materials, systems, processes, conditions, and characteristics of a facility or project.

Hazard and Operability Study (HAZOP). A method to evaluate hazards that uses an interdisciplinary team to examine possible deviations of process parameters from their design intent, and to document the causes and consequences of those deviations.

Limit of Resolution. The scope or depth of investigation into the system reliability.

Preliminary Hazards Assessment. A form-driven HA technique that yields a qualitative description of the hazards related to a process design and qualitatively ranks the hazardous situations. The PHA is most often conducted early in the development of a project when there is little information on design details or operating procedures and is often a precursor to further hazards analyses.

Reliability. The probability that a component, device, equipment and system will perform its intended function for a specified period of time under a given set of conditions. The reliability of a system often includes considering operator error, whereas a component failure does not.

Safety Analysis and Nuclear Engineering (SA&NE). For the purpose of this procedure, the department providing the safety analysis support for various new and existing nuclear facilities.

Safety Class Systems, Structures, and Components (SSC). The designation given to SSC that prevent or mitigate accidents resulting in adverse consequences to the environment or the public or that prevent a criticality.

Safety Documentation. A safety analysis report, preliminary safety evaluation, or supporting analysis for other safety issues, such as an unreviewed safety question (USQ) or a revision to an existing safety analysis report.

Safety Significant SSC. The designation given to SSC with a major function to mitigate or prevent a release of radiological materials and toxic chemicals to onsite workers, the public, or the environment. This includes barriers that contribute to defense-in-depth.

Senior Analysts Advisory Group (SAAG). A group within SA&NE that reviews SA&NE safety documentation when requested. The SAAG provides comments and recommendations on the document's technical adequacy, content, quality, and regulatory compliance.

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Technical Safety Requirements (TSR). Requirements that define the conditions, safe boundaries, and the management or administrative controls necessary to ensure the safe operation of a nuclear facility. A TSR consists of safety limits, operating limits, surveillance requirements, administrative controls, and the use and application instructions.

Unreviewed Safety Question. A condition determined by a safety evaluation showing that changes made to an existing facility, the facility's procedures, or any planned tests or experiments (not described in the existing safety basis) are outside the facility's authorization basis. USQs are processed through existing WHC procedures.

"What-If" Checklist. A form-driven HA technique in which a group of experienced people familiar with the subject process ask questions or voice concerns about possible undesired events.

Worker Safety Events. Events involving hazards routinely encountered in general industry and construction, and for which national consensus codes and/or standards exist to guide safe design and operation without the need for a special analysis to define safety and/or operational parameters. Appendix D provides information and guidelines on worker safety events.

4.0 RESPONSIBILITIES

The SA&NE manager, is responsible for implementing the requirements of this procedure.

The SAAG is responsible for reviewing the SA&NE safety-related documents and to ensure high quality and consistency.

The facility manager or project manager identifies personnel to represent the facility on the HA team, and is responsible for HA issues related to operations, facility engineering, and facility/division regulatory issues.

The safety documentation project engineer serves as facilitator throughout all phases of safety documentation development. The project engineer also acts as an HA team member.

The HA lead is responsible for the following:

- Coordinate the technical activities of the HA team
- Collect and distribute to the HA team all necessary information
 - Facility or project description
 - Radiological and chemical inventory documentation

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- Sources of generic frequency information
 - Sources of hazard evaluation guidelines
 - HA schedule
- Completing the HAD.

5.0 REQUIREMENTS

Each HA team member is required to have the appropriate training, (e.g., radiation training and facility orientation), radiological protection (e.g., mask fit and dosimetry) and necessary security clearances before making any entries on a walkdown.

Necessary information for the HA task includes the following:

- Hazard Categorization per WHC-CM-4-46
- Facility or project and process description document(s)
- Inventory document(s) listing radiological and chemical hazards including form, type, location, quantity, and associated system or subsystem
- Generic facility walkdown information
- Information related to historical events, such as occurrence reports, and accident reports
- Generic frequency data
- Any other document, investigation, or inspection that provides necessary information to determine equipment configuration, existence of passive and active safety barriers or material inventory.

6.0 PROCEDURE

A graded approach is used to achieve a thoroughly documented assessment of complex, higher hazard facilities. The selected technique need not be more sophisticated or detailed than is necessary to provide a comprehensive examination of the hazards associated with the facility operations. For example, a simple storage operation may be adequately evaluated by a preliminary hazard analysis or a structured "what-if" analysis. The analyst is under no obligation to perform a complete HAZOP. The level of analytical effort employed is primarily based on the magnitude of the hazard(s), and takes into account system complexity and the degree to which detailed modeling can be meaningfully supported by system definition.

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The HA is a key input to safety SSC and controls classification and accident analysis. It is intended to give the customer sufficient up-front information to determine how to control or mitigate certain hazards to acceptable levels.

6.1 SELECTION OF HAZARDS EVALUATION TECHNIQUES

DOE-STD-3009 states that hazard evaluation techniques are selected based on the hazardous material inventory and complexity of the facility. Appendix A provides information about the facility/project to assist in choosing the HA technique. Guidelines for selecting the appropriate HA technique are shown in Appendix B.

Small or limited inventories of hazardous material or facilities of limited complexity should be evaluated with a technique such as a PHA or a limited HAZOP. In some cases what if checklists may be appropriate (see Appendix C).

Complex facilities or facilities with significant hazardous material inventories require more detailed techniques such as a HAZOP study, PHA, fault tree analysis, or an FMEA. In many cases, a combination of techniques will be required to adequately evaluate the hazards.

A graded approach needs to be applied to all hazards evaluations. The actual selection of a techniques will be made through a process of negotiation between the HA lead, safety documentation project engineer, and the manager of the facility of concern.

6.2 ESTABLISHMENT OF THE HA TEAM

The facility personnel and/or project personnel assigned to the team should participate for the duration of the HA. The personnel assigned to the team by the facility manager are responsible for communicating with facility personnel to clarify questions about the facility and to facilitate the final review of the HA. The number of HA team members varies depending on the actual project requirements, and may include, on an as-required basis, representatives from the following disciplines:

- Accident analysis
- Fire protection
- Criticality safety
- Radiation control
- Structural mechanics

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- Emergency preparedness hazard analysis
- TSR development
- Quality assurance
- Other areas as dictated by the complexity of the project/facility.

6.3 COLLECTION OF HAZARDS DATA

Hazard identification is a comprehensive, systematic process by which all known facility or project hazards (hazardous material and energy) are identified and recorded. The identification of preventive and mitigative features for each hazard begins during hazard identification.

6.3.1 Facility Information

6.3.1.1 Physical and Information Walkdowns. The HA lead coordinates the facility walkdowns which include both physical and information (paper) walkdowns.

Physical walkdowns permit the team to become familiar with actual facility systems, processes, practices, equipment, and inventory, when applicable. Physical walkdowns are not possible for projects in the design stage. An information or paper walkdown is when HA team members review the facility or project description and process documentation, existing safety documentation, design/system drawings, and procedures in the context of hazard identification. The team performs physical and/or information walkdowns to identify hazardous materials and energy sources. The list in Appendix E provides a list of hazard energy sources and hazardous materials to consider during a facility walkdown or project information gathering.

6.3.1.2 Preparation for the Facility Walkdown. In preparation for the facility walkdown, team members associated with the walkdown review the following list of facility-related items before attempting a physical walkdown of the plant:

- Administrative or operating procedures
- Previous safety analyses
- Facility description manuals
- Engineering drawings
- Occurrence reports
- Emergency procedures
- Test procedures
- Maintenance procedures
- Training records.

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6.3.1.3 Interviews. Interviews are held with designers, engineers, managers, technicians, and any other necessary individual to resolve questions before performing a walkdown.

6.3.1.4 Checklist Preparation. A checklist of concerns, questions, and topics related to safety assurance is developed from the preparation for the facility walkdown.

6.3.1.5 Visit Arrangements. The HA team performing a facility walkdown is accompanied by experienced operations personnel.

NOTE: Well coordinated arrangements should be made several days in advance in order to minimize the number of facility walkdowns required.

6.3.1.7 Human Reliability Considerations. The team may ask that operations proceed with a simulated or dry-run of randomly chosen procedures in order to observe the following:

- Correct version of the procedure is used
- Procedure is readable (i.e., not physically damaged)
- Equipment is labeled as called out in the procedure
- Position instrumentation is functioning properly.

Additional considerations for the team include review of the following:

- Operators have been trained in accordance with any procedural requirements
- Instruments used are within calibration dates
- Instruments are not physically damaged and are capable of intended function
- Alarms associated with instruments are not disabled or set incorrectly.

6.3.1.7 Information Walkdown. The information walkdown includes consultation with facility, system, design, and/or process experts, as applicable and a review of the following:

- Facility or project description
- Hazardous material inventory records
- Existing safety documentation (e.g., preliminary hazards analysis, safety analysis reports (SARs), basis for interim operations, TSRs, technical standards, project design documents, and fire hazards analysis).

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6.3.2 Hazards Material Inventory

An inventory document listing all known radiological and chemical hazards should be completed before starting the undesirable event identification portion of the HA (Section 6.4.1). The inventory provides key input to the remainder of the HA. For purposes of hazard identification, a chemical mixing study may be required to identify additional hazards, depending on the quantities and types of chemicals identified in the inventory document. However, for efficiency, resource chemical mixing studies should be limited to a maximum of two chemicals unless there are compelling reasons.

6.4 ANALYSIS

For purposes of clarity the Hazards Evaluation process is described below in two parts. Figure 1 shows a general flow diagram for a HA.

6.4.1 Undesirable Event Identification Techniques--Hazards Evaluation Part 1

The undesired event identification technique used depends on the level of detail required. The following information must be determined for each undesired event:

1. Material or energy type and quantity
2. Location of hazard
3. Cause of the event (initiator)
4. Consequence of the event (unmitigated)
5. Existing preventive or mitigative features (including administrative controls)
6. Frequency of the initiator
7. Frequency of the mitigated event
8. Consequence of the mitigated event.

The first five items provide information that will specify the event sequences. The last three items permit evaluation of the frequency and severity (combined to represent risk) of the undesired event. Item six provides information used to specify the level of control that will be applied to preventative and mitigative features. Failure to capture this

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information will handicap the rest of the hazards analysis process. The hazard identification/evaluation technique is documented and identifies the participants and evaluation scope, material at risk, major assumptions, and references.

6.4.1.1 Form-Driven and Diagram-Driven Techniques. These techniques are used in undesirable event identification. Diagram-driven techniques are best used when reliability considerations play a large role in the facility and/or system design. Tree analysis allows deeper insights into the causes of failures and their prevention, including crude approximations of human reliability. The premise is that losses (financial, equipment, public, and environmental) can be averted through methods that address component interaction, aid in a better understanding of reliability considerations and produce a better final design and/or operation. The most common techniques are described in Appendix C.

6.5 UNDESIRABLE EVENT EVALUATION--HAZARDS EVALUATION PART 2**6.5.1 Consequence and Likelihood Assignment**

Each hazardous condition identified using the selected technique for undesired event identification will be assessed for likelihood and consequence on the basis of the risk acceptance thresholds defined in WHC-CM-4-46, "Nonreactor Facility Safety Analysis Manual." Existing preventative and mitigative features for each hazardous condition also will be described.

The assessment of likelihood and consequence for each hazardous condition is a collective qualitative judgment of the hazard analysis team. The assessment is made for the initial hazard analysis without taking the impacts of preventative and mitigative features into consideration.

The likelihood assessments are made in occurrences per year. The general criteria used for likelihood assessments are as follows:

- F3. The hazardous condition based on the cause(s) postulated has occurred or is likely to occur (frequency of $10^0/\text{yr}$ to $10^{-2}/\text{yr}$)
- F2. The hazardous condition based on the cause(s) postulated is foreseeable, but unlikely (frequency of $10^{-2}/\text{yr}$ to $10^{-4}/\text{yr}$)
- F1. The hazardous condition based on the cause(s) postulated is perhaps possible, but extremely unlikely (frequency of $10^{-4}/\text{yr}$ to $10^{-6}/\text{yr}$)
- F0. The hazardous condition based on the cause(s) postulated is considered too improbable to warrant further consideration.

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The actual frequency ranges for these categories is determined by the threshold value structure contained in WHC-CM-4-46. Frequency assessments for hazardous conditions that are close to the upper limit of a category are conservatively assigned to the higher likelihood category.

The consequence category assessments address potential impacts on health, safety, and the environment. The general criteria for consequence categorization are taken from WHC-CM-4-46 and are as follows:

- S3. Based on the material at risk and cause(s) postulated, there is sufficient material and release energy to impact a receptor at the Hanford Site boundary
- S2. Based on the material at risk and cause(s) postulated, there is sufficient material and energy to impact a receptor 100 meters from the source of the material at risk
- S1. Based on the material at risk and cause(s) postulated, the release is confined to the facility where it occurred
- S0. Based on the material at risk and cause(s) postulated, there is insufficient material released to affect facility workers.

Estimates of environmental impacts are categorized using the following:

- E3. All S3 hazardous conditions or major leaks from large storage tanks
- E2. All S2 hazardous conditions or liquid releases or leaks outside facility boundaries
- E1. Postulated releases not included in E3 or E2
- E0. No release postulated.

The more severe consequence categories include the less severe consequences. For example, a hazardous condition assessed as having onsite consequences (S2) is also considered to have facility worker consequences (S1).

6.5.2 Candidate Accident Identification

The hazardous conditions identified by the hazard evaluation are used to select candidate accidents for more detailed quantitative analysis. The general selection criteria used are consistent with DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility*

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Safety Analysis Reports: "The range of accident scenarios analyzed in a SAR should be such that a complete set of bounding conditions to define the envelope of accident conditions to which the operation could be subjected are evaluated and documented."

The concept of selecting candidate accidents from all the hazardous conditions identified is based on the feasibility of characterizing risk and developing controls from a representative set of accidents. An accident is considered to be representative of a set of accidents if it has similar accident release characteristics and/or involves similar accident phenomena. Representative accidents that present the most severe consequences and the highest risk (combination of frequency and consequence) are selected.

Representative accidents will be selected based on the following criteria: accidents that bound those of lesser but similar potential consequences; accidents that represent the highest risk; and other accidents, not necessarily bounding, that represent accidents presenting some unique but important phenomenological challenge to system safety. The selection process consists of the following:

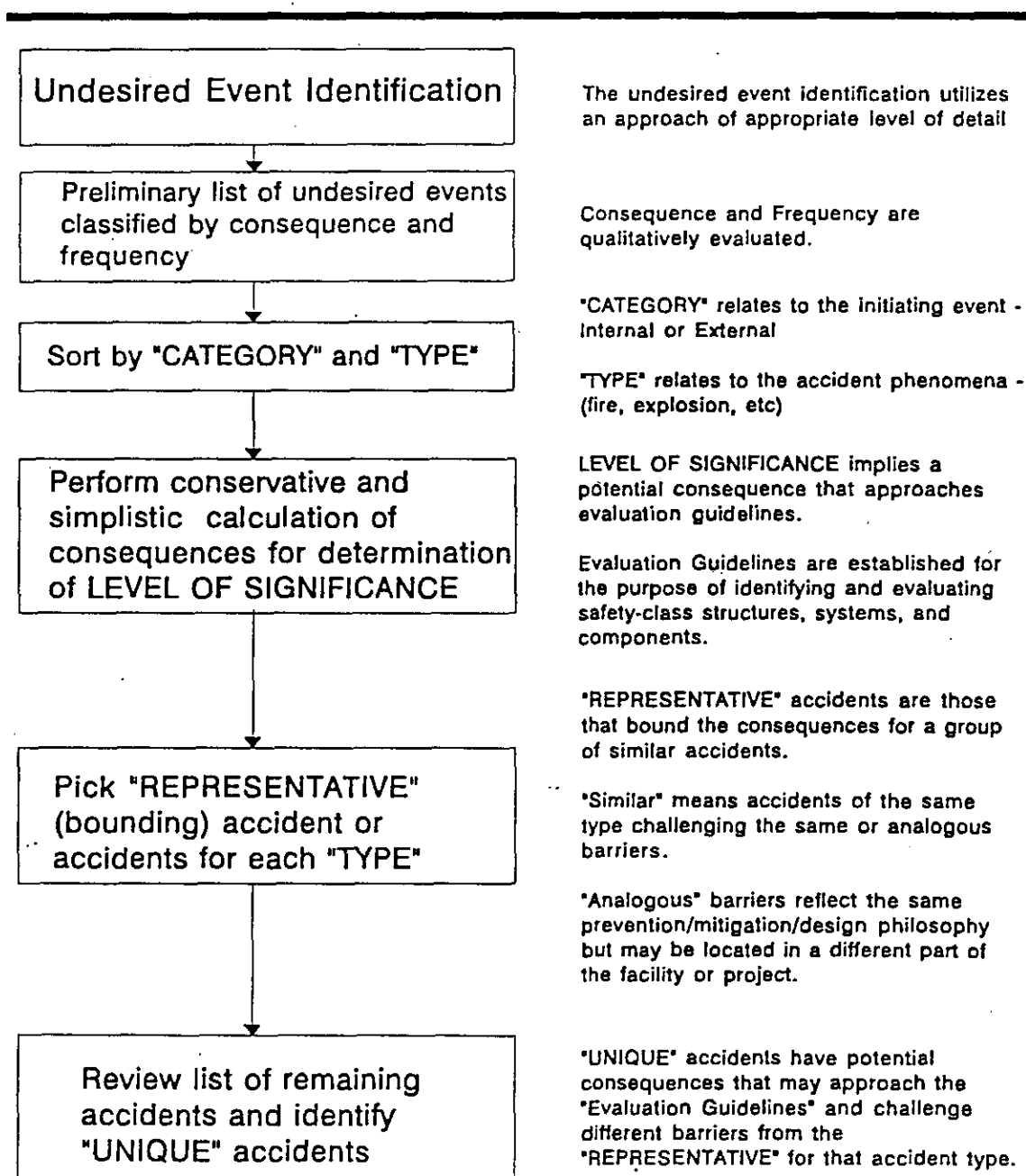
1. Initial Screening. Hazardous conditions are qualitatively assessed as S3, S2, S1, and S0.
2. Assignment of Accident Release Attributes. Hazards are identified by the attributes of energy (high, medium, or low), location (ie, atmospheric, surface, subsurface), and form (aerosol, liquid, or solid).
3. Creation of Hazardous Condition Cause Bins. The cause bins are necessary to segregate hazardous conditions by their initiators such as are fires, explosions, natural phenomena, human error, or criticality.
4. Sorting of the Hazardous Conditions by Cause. Hazardous conditions are next organized by cause. This results in grouping by common accident phenomena (e.g., fire and criticality).
5. Selection of Representative Bounding Accidents From Each Cause Bin. Within each cause attribute bin, the most severe accident in terms of consequence, and the highest risk accident considering likelihood and consequences, are selected. In some cases they are the same accident.
6. Selection of Unique Accidents. Accidents are selected to represent additional unique causes within each general cause attribute bin. This is done to support the development of controls for accidents with similar consequences, but with different barriers being challenged.

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The risks of a facility/activity are characterized and appropriate controls developed based on the detailed analysis of a representative set of accidents in accordance with DOE-STD-3009-94 and using the graded approach.

Figure 1. Flow Diagram of the Hazard Evaluation Process.

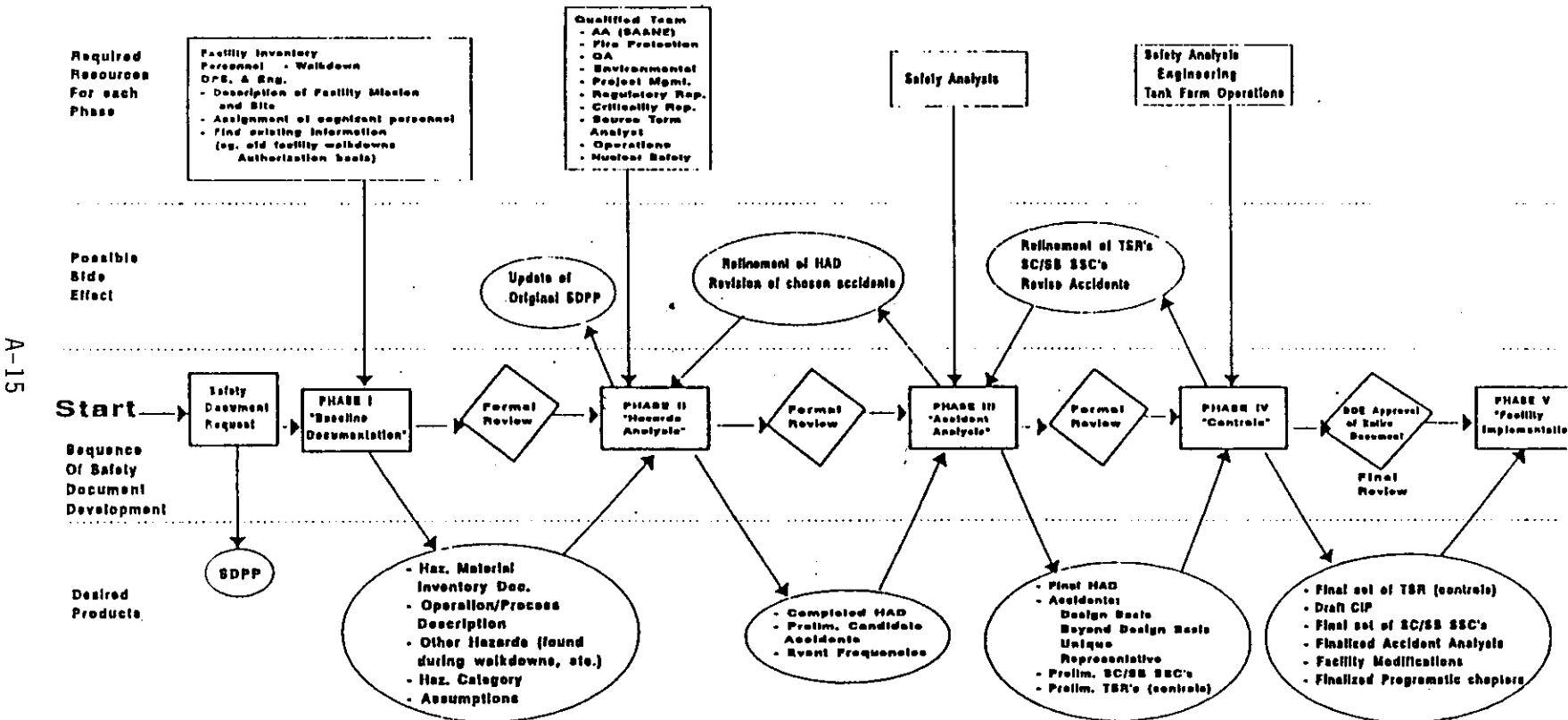
Hazard Evaluation Process



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Adjustments can be made to the actual list of accidents analyzed based on results from accident analysis activities. A table is developed to identify the accidents and the accidents analyzed to accommodate this anticipated situation. The hazardous conditions may be regrouped based on the final set of analyzed accidents.

6.6 HAZARDS ANALYSIS RESULTS

The primary output of the HA task is an HAD (see Appendix F) that includes the following:

- Hazard identification lists the hazards associated with each facility maintained in a database.
- Hazard evaluation describes the accident scenarios, basis for the frequency determination (with and without prevention), basis for the consequence determination (with and without mitigation), discussion of the potential for contamination of the environment, and identification of specifically credited engineered features and administrative controls.
- All accidents not selected as candidate accidents are maintained in the database.

Information provided to the accident analysis task includes the following:

- Candidate Accidents. The final list of candidate accidents represents all the S3, S2, and S1 hazardous conditions identified by the HA. The format for the accidents is shown in the hazards analysis summary (see Appendix F).
- SSC, TSRs, and Defense-in-Depth. Preliminary safety SSC, TSRs, and other controls providing defense-in-depth are documented in tabular form on the same table that shows the hazards analysis summary (see Appendix F).

The HA is a living document and may be revised and updated as a result of discoveries made in the accident analysis phase.

7.0 REFERENCES

- AICHE, 1992, *Guidelines for Hazard Evaluation Procedures*, American Institute of Chemical Engineers, New York, New York.
- DOE-STD-3009-94, 1994, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis*, U.S. Department of Energy, Washington, DC.

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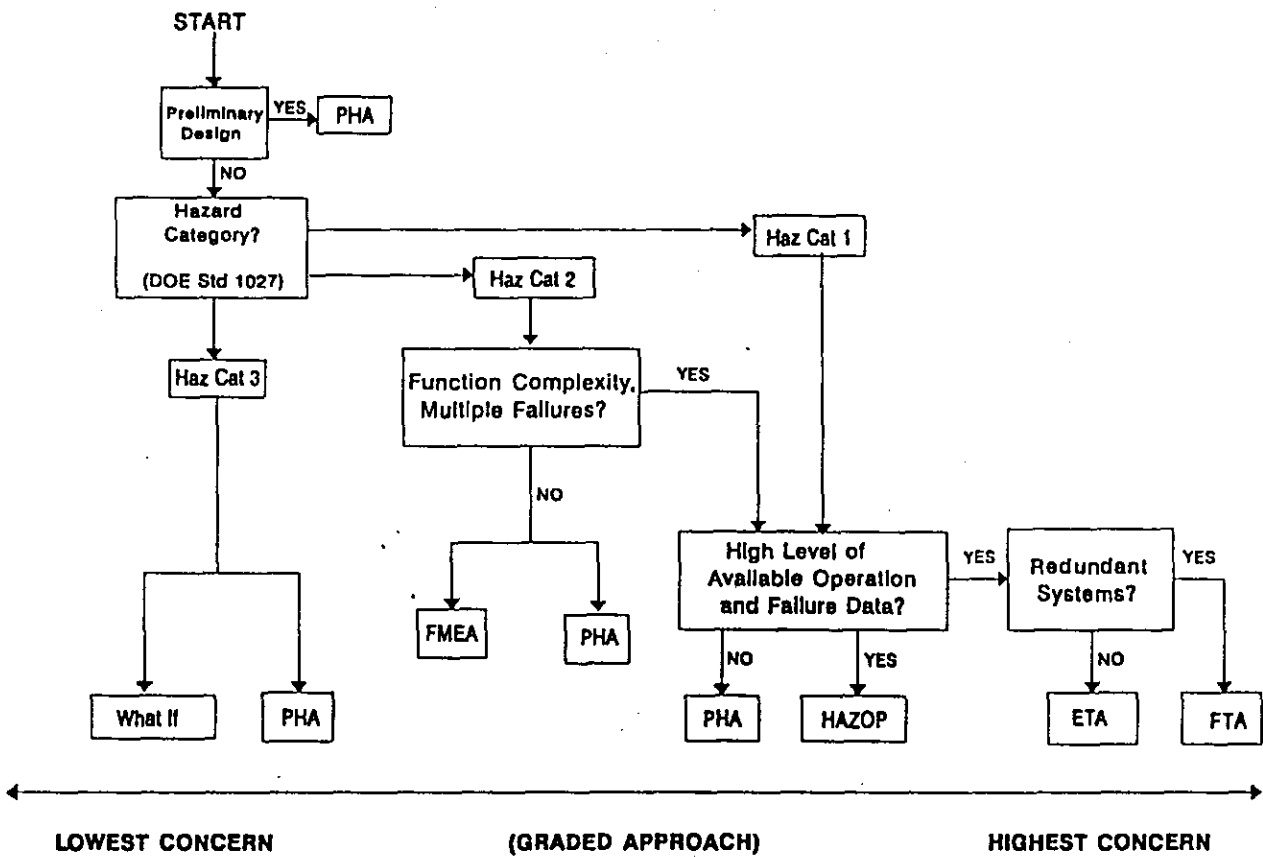
APPENDIX A

SELECTION CRITERIA

DEFINE MOTIVATION			
<input type="checkbox"/> New review <input type="checkbox"/> Recurrent review <input type="checkbox"/> Special requirement			
DETERMINE TYPE OF RESULTS NEEDED			
<input type="checkbox"/> List of hazards <input type="checkbox"/> Hazard screening <input type="checkbox"/> List of accidents <input type="checkbox"/> Action items <input type="checkbox"/> Prioritization of results			
IDENTIFY PROCESS INFORMATION			
<input type="checkbox"/> Materials <input type="checkbox"/> Chemistry <input type="checkbox"/> Inventories <input type="checkbox"/> Similar experience <input type="checkbox"/> PFD <input type="checkbox"/> P&ID <input type="checkbox"/> Existing process <input type="checkbox"/> Procedures <input type="checkbox"/> Operating history			
EXAMINE CHARACTERISTICS OF THE PROBLEM			
Complexity/size <input type="checkbox"/> simple/small <input type="checkbox"/> complex/large		Type of process <input type="checkbox"/> chemical <input type="checkbox"/> physical <input type="checkbox"/> mechanical <input type="checkbox"/> electrical <input type="checkbox"/> electronic <input type="checkbox"/> computer <input type="checkbox"/> human	
Type of operation <input type="checkbox"/> fixed facility <input type="checkbox"/> permanent <input type="checkbox"/> transportation <input type="checkbox"/> temporary		Nature of hazard <input type="checkbox"/> toxicity <input type="checkbox"/> flammability <input type="checkbox"/> explosivity <input type="checkbox"/> reactivity <input type="checkbox"/> radioactivity <input type="checkbox"/> other	
Situation/accident/event of concern <input type="checkbox"/> single failure <input type="checkbox"/> multiple failure <input type="checkbox"/> simple loss of containment event <input type="checkbox"/> loss of function event <input type="checkbox"/> process upset <input type="checkbox"/> hardware <input type="checkbox"/> procedure <input type="checkbox"/> software <input type="checkbox"/> human			
CONSIDER PERCEIVED RISK AND EXPERIENCE			
Length of experience <input type="checkbox"/> long <input type="checkbox"/> short <input type="checkbox"/> none <input type="checkbox"/> only with similar process	Accident experience <input type="checkbox"/> current <input type="checkbox"/> many <input type="checkbox"/> few <input type="checkbox"/> none	Relevance of experience <input type="checkbox"/> no changes <input type="checkbox"/> few changes <input type="checkbox"/> many changes	Perceived risk <input type="checkbox"/> high <input type="checkbox"/> medium <input type="checkbox"/> low
CONSIDER RESOURCES AND PREFERENCES			
<input type="checkbox"/> Availability of skilled personnel <input type="checkbox"/> Time requirements <input type="checkbox"/> Funding necessary <input type="checkbox"/> Analyst/management preference			
SELECT THE TECHNIQUE (See Appendix B Guidelines)			

APPENDIX B

ANALYSIS TECHNIQUE SELECTION GUIDELINES



NOTE: Management and/or the customer can still request an analysis method for a greater concern (a higher degree of rigor than this diagram shows).

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APPENDIX C

HAZARD ANALYSIS TECHNIQUES

1.0 PRELIMINARY HAZARD ANALYSIS

A Preliminary Hazard Analysis (PHA) is a technique derived from the U.S. Military Standard System Safety Program Requirements. This technique uses a form-driven approach that helps ensure standardization and completeness. A PHA focuses in a general way on the hazardous materials and major process areas of a plant. Although, the PHA technique is normally used in the preliminary phase of plant development for cases where experience provides little or no insight into potential safety problems, it may also be helpful when analyzing large existing facilities or when prioritizing selected hazards when circumstances prevent a more extensive technique from being used. A PHA can be performed by one or two people who have a process safety background.

A list of hazards and generic hazardous situations are considered using the following process characteristics:

- Raw materials
- Intermediate and final products (and their reactivity)
- Plant equipment
- Facility layout
- Operating environment
- Operational activities (e.g., testing and maintenance)
- Interfaces among system components.

A PHA yields a qualitative description of the hazards related to a process design. A PHA also provides a qualitative ranking of hazardous situations that can be used to prioritize recommendations for reducing or eliminating hazards in subsequent phases of the life cycle of the process.

Using the PHA technique requires that analysts have access to available plant design criteria, equipment specifications, material specifications, and other sources of information. Table C-1 shows an example of a form used in the PHA process. AICHE (1992), gives a more detailed description of this technique.

2.0 WHAT-IF ANALYSIS

The what-if analysis technique is a brainstorming approach in which a group of experienced people familiar with the subject process ask questions or voice concerns about possible undesired events. It is not as inherently structured as some other techniques (e.g., HAZOP Analysis and FMEA). Instead, it requires the analyst to adapt the basic concept to the specific application. This technique is a form-driven approach.

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Since what-if analysis is so flexible, it can be performed at any stage of the process, using whatever process information and knowledge available. For each area of the process, two or three people should be assigned to perform the analysis. However, a larger team may be preferred. It is better to use a large group for a complex process, dividing the process into smaller pieces, than to use a small group for a long time on the whole process.

The what-if analysis concept encourages the HA team to think of questions that begin with "What-If." However, any process safety concern can be voiced, even if it is not phrased as a question. Usually a scribe records all of the questions, then the questions are divided into specific areas of investigation (usually related to consequences of interest), such as electrical safety, fire protection, or personnel safety. Each area is subsequently addressed by a team of knowledgeable people. The questions are formulated based on experience and applied to existing drawings and process descriptions: for an operating plant, the investigation may include interviews with plant staff not represented on the HA team.

The form for a what-if analysis will tend to be similar to the form used for a PHA. AICHE (1992), gives a more detailed description of this technique.

3.0 HAZARDS AND OPERABILITY ANALYSIS

The HAZOP technique is a form-driven approach developed to identify and evaluate safety hazards in a process plant, and to identify operability problems that, although not hazardous, could compromise the plant's ability to achieve design productivity. Although originally developed to anticipate hazards and operability problems for technology with which organizations have little experience, it has been found to be very effective for use with existing operations. Limitations of the HAZOP method vary, but the limitations most commonly encountered are time and resource related. The completion of a HAZOP study is time consuming, and depending on the complexity of the failure being investigated, it can require considerable resources (e.g., personnel, information, and software). Use of the HAZOP Technique requires a detailed source of information concerning the design and operation of a process.

In HAZOP analysis, an interdisciplinary team uses a creative, systematic approach to identify hazard and operability problems resulting from deviations from the process design intent that could lead to undesirable consequences. An experienced team leader systematically guides the team through the plant design using a fixed set of words (called guide words). These guide words are applied at specific points or study nodes in the plant design and are combined with specific process parameters to identify potential deviations from the plant's intended operation.

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Table C-2, shows an example of a HAZOP form. AICHE (1992) gives a more detailed description of this technique.

4.0 FAILURE MODES AND EFFECTS ANALYSIS

A Failure Modes and Effects Analysis (FMEA) tabulates failure modes of equipment and their effects on a system or plant. The failure mode describes how equipment fails (e.g., open, closed, on, off, and leaks). The effect of the failure mode is determined by the system's response to the equipment failure. An FMEA identifies single failure modes that either directly result in or contribute significantly to an accident. Human (operator) errors are usually not examined directly in an FMEA; however, the effects of a misoperation as a result of human error are usually indicated by an equipment failure mode. An FMEA is not efficient for identifying an exhaustive list of combinations of equipment failures that lead to accidents.

The FMEA generates a qualitative, systematic reference list of equipment, failure modes, and effects. A worst-case estimate of consequences resulting from single failures is included. The FMEA may be easily updated for design changes or system/plant modifications. FMEA results, including suggestions for improving safety in appropriate items, are usually documented in table format.

The FMEA method consists of filling in information listed in Table C-3 using the following:

1. Location of components of interest and some identification number or name associated with that component of interest.
2. A brief description of the component (e.g., double-pole breaker, globe valve, indication light, and instrument cut-out valve)
3. All the potential failure modes that could be associated with the component (e.g., switches fail open or closed, valves fail open or shut).
4. Understanding how the component works or affects other components, systems, or facilities via inspection of engineering drawings and documents, and if necessary, consultation with the engineer or vendor responsible.

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5. Comments: a column is typically included, so the analyst can note current or impending component conditions, as well as describe needs such as other analyses. References information (e.g., engineer, vendor, document, and engineering drawing) has been included in this column, depending on the size of the analysis. Any information that the analyst believes to be important in the construction of a defensible hazard evaluation that has not been entered into the table needs to be concisely entered here.

AICHE (1992) gives a more detailed description of this technique.

5.0 FAULT TREE ANALYSIS

The fault tree analysis is a diagram-driven method. Fault tree analysis provides insight into component dependence or interaction and documents the analysis. Fault tree analysis for an HA does not include probability determinations.

Limitations of the fault tree vary, but those most commonly encountered are time and resource related. The construction of a fault tree is time consuming, and depending on the complexity of the failure being investigated, it can require considerable resources (e.g., personnel, information, and software). If the analysis is sensitive to end-product conditions, it requires boundaries and limits of resolution to be defined before starting the analysis.

When conducted correctly, the fault tree finds common failure modes, and multiple failure modes that would be missed by most other analyses. It is possible to include human factor considerations in the analysis.

The following is a very succinct presentation of the fault tree analysis. A much more in-depth understanding of the method can be found in the *Fault Tree Handbook* (Roberts, et al. 1981).

1. Present clear distinct statement defining the failure being analyzed. This statement is referred to as the top event.
2. Develop each subsequent level of the fault tree and systematically deduce the intermediate events that, with failure, either produce or contribute to the production of the event of the previous level.

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3. Once the events have been determined and placed at the appropriate level in the fault tree, connect a logic gate from the upper event to the lower intermediate or basic events. Only one gate follows an event, but it can precede many events, as long as those events constitute one level of the fault tree.
 - If all the intermediate events must fail to achieve the top event failure, then the gate will be an and-gate.
 - If only one of the intermediate events can cause the top event by failing, then an or-gate is used.
4. For the next level, further identify intermediate events that can be logically deduced to either produce or contribute to the occurrence of the former event, then determine and add the appropriate logic gates to the fault tree. This cycle of determining events and adding gates continues until there are no more intermediate events to be deduced (i.e., the limit of resolution has been reached).
5. If sufficient information, such as a definite failure mode and an adequate understanding of the probability or failure rate has been produced, the event is shown as a basic event.
6. If the results from the event are indeterminate or there is no adequate understanding of the probabilities and/or failure rates associated with the event, the event is shown as an undeveloped or indeterminate event.

6.0 Event Tree Analysis

The event tree analysis is another diagram-driven method. Event tree analysis provides insight into the consequences that a number of different event sequences produces. Event trees can often be linked to a fault tree analysis, however, this is usually done to give an understanding of the probabilities. The event tree analysis for HA does not include probability determinations (performed in accident analysis).

Limitations of the event tree analysis are similar to those of the fault tree analysis. The construction of an event tree is less time consuming and less resource demanding than a fault tree (depending on the complexity of the sequence being investigated). This method is less sensitive to end-product conditions, but still requires boundaries and limits of resolution to be defined before starting the analysis.

When conducted correctly, the event tree analysis finds all possible outcomes to any particular initiating event. Furthermore, it is possible to include human factor considerations in the analysis.

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The following is a simple presentation of the event tree analysis. A basic understanding of the method can be found in Engineering Safety Assessment (Thompson 1987).

1. Choose one initiating event. The following is a list of initiating events often chosen, however, this list is not all inclusive.
 - Loss of power (e.g., offsite, auxiliary, and emergency back-up)
 - Leakage (e.g., HEPA and catastrophic piping failures)
 - Overpressurization (e.g., relief valve failure)
 - Underpressurization (e.g., vacuum breaker failure)
 - Improper closure (e.g., isolation valves)
 - Improper opening (e.g., isolation valves)
 - Loss (or reduction) in flow (e.g., coolant and feed flow)
 - Various instrument readings and/or failures
 - Natural disasters (e.g., range fires and earthquakes).
2. Determine a component or system that provides mitigation of a release or defense from a release. The successful functioning of this item is referred to as a follow-on event.
3. List all the follow-on events at the top of the event tree, and ensure that the sequential arrangement precludes any problems. For instance, there can be no diesel generator failure until after both the normal power fails (the initiating event) and the alternate power transfer fails.
4. Each follow-on event produces two branches on the tree (one for successful operation and one for failure). The top branch depicts successful operation of the item identified in the follow-on event, and the bottom branch depicts the failure of the item to perform its necessary function.
5. The consequences are listed at the end of the HAZOP table as combinations of success and failure of each of these events. Some events that fail may remove one or more of the other events from further consideration, and in this case, the tree may be simplified by reducing the number of branches accordingly.

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APPENDIX D

WORKER SAFETY EVENT IDENTIFICATION GUIDELINES

1. Worker safety events are of the type and magnitude that are routinely encountered and/or accepted by the public in everyday life.
2. Worker safety events involve hazardous materials or operations encountered in general industry in appropriate applications that are adequately controlled by Occupational Safety and Health Administration regulations or one or more national consensus standards (e.g., American Society of Mechanical Engineers, American National Standards Institute, National Fire Protection Association, Institute for Electrical and Electronic Engineers, National Electrical Code), where these standards are adequate to define special safety requirements, unless in quantities or situations that initiate events with serious impact to the public, workers, or the environment.
3. Hazards such as noise, electricity, flammable materials, welding operations, small quantities of chemicals that would likely be found in homes or general retail outlets, and hazardous materials transported on the open road in Department of Transportation specification containers are considered to be worker safety events encountered in everyday life.

Worker safety events must be considered as initiators for accidents involving other types of hazards. For example, flammable materials may be at first screened out, however, if the flammable materials could potentially cause a fire that releases toxic materials, the flammable materials must be considered as a potential initiator for a toxic material release.

Examples of worker safety events are those involving the following:

- Specific materials (e.g., lead and asbestos) that have their own control program
- Thermal energy sources (potential for burns)
- Hazards typically found in machine shops
- Fork lifts
- Cranes
- Gas cylinders transported and stored in Department of Transportation configuration and within design limits unless they are stored in large (hundreds) quantities

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- Personnel pinches, trips, falls, and slips
- Confined space hazards
- Hazards typically found in office areas
- Mechanical presses.

Additional guidance on worker safety events determination:

X-ray Equipment. The intent is to screen out those facilities with X-ray equipment that are commercially available, conform to appropriate national codes and standards (e.g., ANS N537/NBS123) for X-ray equipment and have not been modified with regard to safety-related design and operating features such as voltage and shielding. If the X-ray system does not conform to the appropriate national code standard, then it must be kept for further hazard analysis.

Lasers. The intent is to screen out Class I and Class II lasers (per ANSI Z136.1) and Class III lasers with enclosed beams because these do not represent a significant health threat. If these Class I, II, and III laser systems do not conform to the appropriate national standard then they must be kept for further hazard analysis. Class III lasers with non-enclosed beams and Class IV lasers are to be kept for further analysis. Gas supplies that are an integral part of an unmodified, sealed purchased system design do not have to be treated separately; however, gas supplies that are not sealed in the purchased system or systems that have been modified must be considered separately as appropriate (i.e., toxic material criteria).

Electrical. The intent is to screen out standard electrical hazards but to retain for further analysis those that represent special safety concerns. Systems to be retained are (1) those with 600V or more and 2.5 mA or more output, and (2) stored energy systems with 50J or more stored energy and terminal-to-terminal voltage of 600V or more. The National Electric Code (NEC 70-1990) identifies these as systems requiring special consideration.

Kinetic Energy. There are many situations in our facilities in which there exist sufficient amounts of kinetic energy to seriously injure personnel (e.g., cars, trucks, cranes, and machinery). However, these should be screened out as normal industrial hazards. Only unusual or unique high kinetic energy systems (e.g., large centrifuges and high-speed massive flywheels) should be kept for further analysis.

Pressure. The intent is to screen out normal hydraulic systems, plant air systems, etc., and to retain only those systems, either gas or liquid, that have pressures greater than 210.92 kgf/cm² (3,000 lbf/in²) or stored energy greater than 0.004 kg (0.1 lb) TNT. Special high pressure design and operating considerations are required above these levels.

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Temperature. The intent is to screen out high temperature systems when the only consequence is a contact burn and to keep for further analysis systems (1) that could result in a strong overpressure if a coolant or other fluid contacted the high temperature mass or (2) that could cause toxic products if materials in the area were exposed to the high temperature or (3) that could cause a fire that would spread radioactive or toxic materials.

Biohazards. The intent is to screen out common sources of biohazards such as cooling towers but to retain for further analysis facilities containing biohazards of such a nature that special industrial hygiene controls (protective clothing, breathing apparatus, special warning placards) are required.

Asphyxiant. Asphyxiants do not have threshold limit values and, therefore, cannot be handled as toxic materials. Consider whether there are ready wells to entrap asphyxiants and unsuspecting personnel or situations that would impact large numbers of people. Cylinders of compressed asphyxiants should be included in these evaluations. Such situations should be kept for further analysis, specifically those situations in which the oxygen level would be less than 18% resulting from increased asphyxiant gas concentration.

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APPENDIX E

HAZARD ENERGY SOURCE AND MATERIAL LIST

Group	Hazard Energy Source
Electrical	Battery banks Cable runs Diesel units Electrical equipment Hot plates Heaters High voltage Locomotive, electrical Motors Pumps Power tools Switchgear Service outlets, fittings Transformers Transmission lines Underground wiring Wiring
Thermal	Bunsen burner/hot plates Electrical equipment Furnaces Heaters Steam lines Welding torch
Friction	Belts Bearings Fans Gears Motors Power tools
Pyrophoric Material	Pu and U metal
Spontaneous Combustion	Nitric acid and organics
Open Flame	Bunsen burners
Flammables	Flammable gases Flammable liquids
Combustibles	Combustible materials

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Group	Hazard Energy Source
Chemical Reactions	Uncontrolled chemical reactions
Potential (pressure)	Gas bottles Gas receivers Pressure vessels Steam headers and lines
Explosive Material	Explosive gases Hydrogen Propane Explosive chemicals
Radiological Material	Radiological material
Hazardous Material	Alkali metals Asphyxiants Biologicals Carcinogens Corrosives Oxidizers Toxics
Ionizing Radiation Sources	Fissile material Radiography equipment Radioactive material Radioactive sources
Fissile Material	Fissile material
Non-facility Events	Explosion Fire Other
Vehicles in Motion	Airplane Helicopter Train Truck/car
Crane	Crane
Natural Phenomena	Earthquake Flood Lightning Rain Snow, freezing weather Straight wind Tornado

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APPENDIX F

HAZARDS ANALYSIS SUMMARY

Instructions for recording information are listed in Table F-1, "Hazard Analysis Summary." All tables are shown at the end of this appendix.

Table F-1 provides a format for recording information obtained during the hazard analysis process. Table F-1 has the columns identified by letters in parenthesis. The following instructions are lettered to correspond to the lettered columns and describe the intended information to be recorded.

- (A) This column is intended to identify the hazard associated with the specific event being summarized. Hazards are materials, energies, or conditions that could, if not appropriately controlled, cause harm to persons or the environment. Table F-2 provides examples of hazards.
- (B) The event number is a unique number assigned to an accident scenario. This number is arbitrary, but should be structured to allow identification of the methodology used if multiple hazard evaluations are present in the hazard analysis. Additional detail in the event number identifies the section of the hazard evaluation from which the event was derived.
- (C) The event category is meant to record the type of initiator that could cause the event. The three categories are:
 - Natural phenomena (NAT). e.g., lightning, earthquake, high wind, and tornado.
 - External event (EXT). Events caused by human sources outside the facilities of interest such as aircraft crash, vehicle crash, gas pipeline ruptures, etc.
 - Internal event (INT). These are events caused within the facility that may be process related, human error etc.
- (D) The postulated event description is meant to capture the accident sequence in a straight forward manner. The description should be put in the following form:

Release of [type of material such as "radioactive aerosols"] from [where the material is released such as "transfer pipe which runs from DCRT to DST"] due to [the cause of the event, such as "spray leak into underground structure during transfer"].

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- (E) The significant causes or energy sources column provides additional information relating to the accident sequence. Possible entries would be human error, mechanical failure, material failure, design flaw, flammable gas detonation, etc. Use this column to provide information related to the selection of controls that are presented in following columns.
- (F) The receptor column requires no entries except for the potential for contamination of the environment portion. The receptor is the individual affected by the accident. The definitions of the receptors are contained in Table F-3. In environmental contamination concerns, a short statement of the estimated level is entered along with the E designator determined from Table F-4.
- (G) The credited prevention column is, in the final phase of the hazards analysis, to be filled in with features identified as items required for accident prevention. These are only items that are controlled under an approved quality assurance program of mandatory compliance. However, in the initial phases of a hazard analysis, this column can be used to identify all possible features that could be used to prevent the accident from occurring.
- (H) The scenario frequency columns are to be filled in with the code for the qualitative frequency established for the event sequence. Table F-5 contains the definitions of the frequency codes. Only one code is placed in each column. The frequency relates to the highest consequence of the event sequence. Frequency without prevention is determined by the initiator frequency only. Frequency with prevention takes into account the effectiveness of the credited prevention features. When the final set of credited prevention features is determined, the "with prevention" frequency will only reflect the effect that these features will produce. No credit for defense-in-depth features shall be taken.
- (I) As with the credited prevention column, the credited mitigation column is, in the final phase of the hazards analysis, filled in with only those features required to mitigate the consequences. However, in the initial phases, this column can be used to identify all possible features that could be used to mitigate the accident.
- (J) The consequences column identifies the consequences of the event. If the consequence "without mitigation" has been determined as S3 (offsite public effect) then Y is placed in the box associated with public; if not, an NA is entered. The "with mitigation" case is also evaluated and documented. The letter is also placed in any row following the highest marked affected receptor. Therefore, if a Y is placed in the public row, then a Y is also placed in the co-located worker row and the immediate worker row. If a Y is only placed in the immediate worker row, NA would be entered in the other rows.

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- (K) The risk bin number is obtained from Table F-6 and is a function of the consequence and frequency.
- (L) Defense-in-depth information is recorded in this column. Defense-in-depth will not document all features that have been identified throughout the hazards analysis process. Instead, it is the selected subset of all remaining features not specified as "credited" which have been agreed are appropriate for inclusion in the safety documentation.

This column is normally completed after final decisions have been made regarding the credited prevention and credited mitigation features.

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Table F-1. Hazard Analysis Summary.

(A) Hazard	(B) Event No.	(C) Event Category	(D) Postulated Event Description	(E) Significant Causes or Energy Sources	(F) Receptor	(G) Credited Prevention (Attributes that Lower Frequency)	(H) Scenario Frequency		(I) Credited Mitigation (Attributes that Lower Consequences)	(J) Consequences		(K) Risk Bin Number		(L) Defense-in-Depth Engineered Features and Administrative Controls
							Without Prevention	With Prevention		Without Mitigation	With Mitigation	Without Prevention Mitigation	With Prevention Mitigation	
Radio-active materials in tank waste					Public	Engineered Features:			Engineered Features:					
						Administrative Features:			Administrative Features:					
					Co-located Worker	Engineered Features:			Engineered Features:					
						Administrative Features:			Administrative Features:					
	Immediate Worker	Engineered Features:	Engineered Features:	Engineered Features:										
						Administrative Features:			Administrative Features:					
Potential for contamination of the environment:														
Toxic chemicals in tank waste					Public	Engineered Features:			Engineered Features:					
						Administrative Features:			Administrative Features:					
					Co-located Worker	Engineered Features:			Engineered Features:					
						Administrative Features:			Administrative Features:					
	Immediate Worker	Engineered Features:	Engineered Features:	Engineered Features:										
						Administrative Features:			Administrative Features:					
Potential for contamination of the environment:														

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Table F-2. Examples of Hazards.

<p><u>A Corrosives</u></p> <ul style="list-style-type: none"> Acids Caustic Natural chemicals Decon solution High temperature waste Other <p><u>B Explosives/Pyrophorics</u></p> <ul style="list-style-type: none"> Caps Primer cord Dynamite Scrub chemicals Dusts Hydrogen Gases, other Nitrates Peroxides-superoxides Pu and U metal Sodium Other <p><u>C Nuclear Criticality</u></p> <ul style="list-style-type: none"> Vaults Temporary storage areas Shipping and receiving areas Filters Casks Burial ground Storage racks Canals and basins Decon solution Trucks, forklifts, dollies Hand carry Cranes/lifts Hot cells, assembly, inspection Laboratories Other 	<p><u>D Flammable Materials</u></p> <ul style="list-style-type: none"> Packing materials Rags Gasoline Lube oil Coolant oil Paint solvent Diesel fuel Buildings and contents Trailers and contents Grease Hydrogen Nitric acid Organics Gases-other Liquids-other Other <p><u>E Thermal Radiation</u></p> <ul style="list-style-type: none"> Furnaces and boilers Steam liners Lab equipment Solar Other <p><u>F Chemical Reactions</u></p> <ul style="list-style-type: none"> Uncontrolled chemical reactions Other <p><u>G Friction</u></p> <ul style="list-style-type: none"> Belts Bearings Fans Gears Motors Power tools Other 	<p><u>H Electrical</u></p> <ul style="list-style-type: none"> Battery banks Diesel units Transformers Wiring Switchgear Underground wiring Cable runs Service outlets/fittings Pumps Motors Heaters Power tools Small equipment Electrical equipment Hot plates High voltage Locomotive, electrical Transmission lines Other <p><u>I Kinetic-Rotational</u></p> <ul style="list-style-type: none"> Centrifuges Motors Pumps Cooling tower fans Laundry equipment Shop equipment Other <p><u>J Kinetic-Linear</u></p> <ul style="list-style-type: none"> Cars, trucks, buses Forklifts, dollies, carts Railroad Obstructions Crane loads Pressure vessel blowdown Other 	<p><u>K Mass, Gravity, Height</u></p> <ul style="list-style-type: none"> Human effort Stairs Lifts and cranes Bucket and ladder Trucks Slings Hoists Elevators Jacks Scaffold and ladders Pits and excavations Elevated doors Vessels Other <p><u>L Pressure-Volume</u></p> <ul style="list-style-type: none"> Boilers Surge tanks Autoclave Test loops Gas bottles Pressure vessels Stressed members Gas receivers Negative pressure collapse Steam headers and lines Other <p><u>M Thermal (except radiant)</u></p> <ul style="list-style-type: none"> Convective Exposed components Electric heaters Fire boxes Electric wiring, equip Furnaces Steam lines Welding torch Other
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Table F-3. Safety Consequence Category Designators.

Safety class category designation	Description
S3	Potential significant radiological dose consequences or chemical exposure to the offsite receptor.
S2	Potential significant radiological dose consequences or chemical exposure to the on-site co-located worker.
S1	Potential industrial injury, radiological dose consequences or chemical exposure to the facility worker.
S0	No effect outside the facility confinement systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.

Table F-4. Environmental Consequence Category Designators.

Environmental Class Designation	Description
E3	Environmental discharges of hazardous material outside the Hanford Site boundary or to the groundwater.
E2	Reportable environmental discharge of hazardous material within the Hanford Site boundary associated with an S2 Safety Consequence.
E1	Limited environmental discharge of hazardous material outside a facility associated with an S1 Safety Consequence.
E0	No environmental impact.

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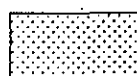
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Table F-5. Frequency Category Designators.

Frequency category designation	Numeric definition	Word definition
F3	$>10^{-2}/\text{year}$	Anticipated
F2	$>10^{-4}$ to $\leq 10^{-2}/\text{year}$	Unlikely
F1	$>10^{-6}$ to $\leq 10^{-4}/\text{year}$	Extremely unlikely
F0	$\leq 10^{-6}/\text{year}$	Beyond extremely unlikely

Table F-6. Risk Matrix Bin Numbers.

Likelihood	Consequences			
	S0	S1	S2	S3
F3	7	11	14	16
F2	4	8	12	15
F1	2	5	9	13
F0	1	3	6	10

Considered for identification of
safety Structures, Systems, and
Components and Technical
Safety Requirements.Requires identification of safety
Structures, Systems, and
Components and Technical
Safety Requirements.

APPENDIX B. PROCEDURE TO FOLLOW FOR DETERMINING RELEASE QUANTITY

(Work Procedure WP-5.13, "Release Quantity," excerpted from the former WHC manual WHC-CM-6-32, *Safety Analysis and Nuclear Engineering Work Procedures*.)

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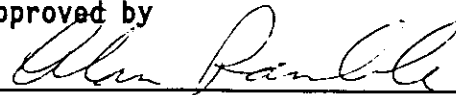
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June 24, 1996

Safety Analysis and
Nuclear Engineering

RELEASE QUANTITY

Approved by


A. L. Ramble, Manager
Safety Analysis and Nuclear
Engineering

1.0 PURPOSE

This procedure defines requirements for the choice of airborne release fractions (ARF), respirable fractions (RF) and leak path fractions (LPF) used to determine the quantity of radioactive or toxicological material released. This procedure provides a consistent approach to determine release quantities and provides a means of using of certain models for information concerning specific types of releases.

2.0 SCOPE

This procedure applies to all documents and expert judgements produced by Safety Analysis and Nuclear Engineering (SA&NE) and their contractors in which the quantity of radioactive or toxicological material is determined.

3.0 DEFINITIONS

Material At Risk (MAR). The fraction of the total facility inventory of radiological or toxicological material that is affected by forces and stresses caused by the event of concern.

Release Quantity. The quantity of the MAR that enters the atmosphere. The release quantity in this procedure is determined by multiplying the MAR by the following:

- The airborne release fraction or rate
- The respirable fraction
- The leak path fraction.

Airborne Release Fraction Or Rate. The fraction of material that is separated from and suspended above the MAR. (There are many mechanisms that separate and suspend materials. Appendix A provides a general discussion.)

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Respirable Fraction. The fraction of the material separated from and suspended above the MAR and contains particles or droplets of a size that is within the respirable range.

Leak Path Fraction. The fraction of the material suspended above the MAR that is transported to the atmosphere.

4.0 RESPONSIBILITIES

The Peer Reviewer and both the Manager and the individual in charge of the analysis are responsible to ensure that the requirements of this procedure are followed.

4.1 SENIOR ANALYSTS ADVISORY GROUP

The SAAG approves the release fraction models cataloged in Appendix B and informs authors when their choice of release fraction differs from others used in similar analyses.

4.2 ANALYST

The analyst must be familiar with the original references used in the development of the ARFs and RFs, not just the Handbooks (Mishima 1994, Sutter 1982, and Ayer 1988). The original references contain the information needed for justification and provide a much better understanding of the phenomena involved.

To determine the release quantity, the author needs to be able to identify and understand the mechanism(s) by which the material is being fractured and released in order to adequately justify the ARF, RF, and LPF.

5.0 REQUIREMENTS

The following calculation is used to find the release quantity:

$$RQ = (MAR)(ARF)(RF)(LPF)$$

where

RQ = the release quantity, grams or Curies
MAR = material at risk = (I)(FA)
I = total inventory within the facility in question
FA = fraction of the inventory affected by the release mechanism of concern

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RELEASE QUANTITY

ARF = airborne release fraction (the fraction of the MAR made airborne)
 RF = respirable fraction (the fraction of the ARF that is respirable)
 LPF = leak path fraction (the fraction of the ARF that is transported
 to the atmosphere)

5.1 ARF AND RF VALUES

The numerical values for ARF and RF are found in many sources and, in some cases, can be analytically determined. Justification of the choice of ARF and RF must be documented, showing that the physical and chemical conditions in the reference used, or in the model developed, are quite similar to those in the release mechanism of concern. Typically, in detailed analyses, two or three ARF or RF references must be documented and discussed in order to develop the ARF or RF used. Most of the time the ARF and RF are obtained from the references in Section 7.0.

ARF and RF values must be based on technically sound, well documented, reviewed information that describes, to the extent possible, the response of the material-of-concern to the specific type of stress. The ideal values would be selected from a mechanistic model of the airborne release of the material-of-concern verified by experimental data over the entire range of concern. There are currently no such data. Values for ARFs and RFs selected from a mechanistic model with experimental verification over a limited range of stress bounding the range postulated for the event would also be very desirable, but are not available.

The airborne release estimate is based upon many independent and interrelated parameters such as the following:

- The actual level of stress generated by the initiating event.
- The response of all materials to the level of stress applied at the specific location postulated in the event. (The actual level of stress applied to the material-of-concern may depend upon the attenuation or enhancement of the level of stress generated by intervening materials.)
- The amount of material-of-concern is actually impacted by the stress (depending on shielding by barriers/obstruction to release.

Thus, the probability of any specific response may vary widely.

Empirical correlations of experimental data over a limited stress range, often for the specific material-of-concern, are available and shall be applied for all applicable cases. First principal models for some noncomplex material events (e.g., venting of pressurized gas from containment) are also available for well characterized phenomena.

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RELEASE QUANTITY**5.2 LEAK PATH FRACTIONS VALUE**

The LPF is frequently assumed to be 1.0. Justification of the LPF (if different from 1.0) must be documented, showing that the physical and chemical conditions in the reference used, or in the model developed, are quite similar to those in the release mechanism of concern.

5.3 DETERMINATION OF THE LEVEL OF DETAIL REQUIRED

The complexity of analysis and accuracy required needs to be assessed because the application of a highly accurate ARF for a complex model is not warranted or useful for an issue at conception or for an opinion.

The requirements for ARF change as the level of required detail and knowledge of the level of stress increases. Some ARF values are only available as a single bounding value or general form due to scarcity of experimental data. Other ARF values are available in general form with considerable detail and lower ARF values may be identified if the level of definition provided is appropriate. Some RF values are based on experiments and are fairly accurate. In other situations, an RF value of 1.0 is assumed.

6.0 PROCEDURE**6.1 SELECTION OF ARFS AND RFS****6.1.1 Standard Phenomena**

In order to characterize the type and level of stress imposed on the material by the initiating and secondary events, the user must identify and understand the mechanisms involved in determining the release quantity. If the stresses associated with the postulated event are standard phenomena (e.g., liquid sprays, free-fall spills of powders and liquids, aerodynamic entrainment) selection is based on textbooks pertaining to the mechanisms/phenomenon and on previous analyses in the same or similar situations.

6.1.2 Simple Bounding Analyses

For simple bounding analyses (e.g., hazards identification, preliminary safety evaluations, quick estimates), compare the stress to those developed in the ARFs and RFs summarized in published documents such as Mishima (1994) or Ayer (1988) or Sutter (1982). If the type of stress is the same as is covered by the summarized value and the stress level is bounded by the experimental basis, the value of ARF or RF are acceptable. Assume that the LPF equals 1.0.

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RELEASE QUANTITY**6.1.3 Detailed Analyses**

For detailed analyses (e.g., safety assessments, safety analysis reports), compare the type and stress level of the accident conditions to a broad information base of ARF experimental parameters available for that type of stress. Use (Mishima (1994), Ayer (1988) and Sutter (1982) to identify the specific experimental reports. (A literature search may identify additional references. Select the ARF and RF that most closely represents and bounds the conditions postulated. The values may be interpolated, but the interpolation must be made with the function of the parameter being varied. Great care must be used in extrapolating ARF values beyond their experimental bases. Use the value of RF that is associated with the ARF chosen. Use an LPF of 1.0 or calculate or argue for a lower value if warranted.

6.1.3 Very Detailed Analyses

If a very detailed analysis is deemed appropriate (e.g., safety assessments or safety analysis reports where the result must be as realistic as possible), perform the analysis described in Section 6.1.2, and, if possible, compare the ARF with the theoretical basis for the suspension mechanism. If the suspension mechanisms cannot be defined, additional refinement is not recommended. If the basis for the suspension can be established, the ARF may be interpolated or extrapolated within some reasonable and defensible range using the proper methodologies. Use the RF that is associated with the ARF chosen. Calculate or argue for a value of LPF that is less than 1.0.

6.1.4 Comparison with Similar Analyses

Compare the ARF value selected with information from other analyses for the same or similar conditions to assure consistency and appropriate conservatism. Document the reasons for any deviations from such comparison of values.

6.1.5 Leak Path Fractions Values

Determine values for LPF qualitatively or by use of a physical model (e.g., depressurization). Qualitative arguments must be persuasive and approved by SAAG when appropriate.

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6.2 SPECIFIC GUIDANCE

6.2.1 Models

Appendix B contains a list of models and ARF and RF information to be used in analyses when appropriate. These models or values are to be used unless arguments are presented that show a more appropriate model for the condition. The models and values in Appendix B have been approved by the SAAG and by SA&NE management. Models or values can be submitted to the SAAG for consideration. The model or value submitted must have the approval of the manager of the individual in charge of the analysis.

6.2.2 Considerations

Certain aspects of accident analysis need to be considered in each analysis. Appendix C provides the list of these aspects. Items can be added to the list with the approval of the SAAG.

7.0 REFERENCES

- Ayer, J. E., A. T. Clark, P. Loysen, M. Y. Ballinger, J. Mishima, P. C. Owczarski, W. S. Gregory and B. D. Nichols, 1988 *Nuclear Fuel Cycle Accident Analysis Handbook*, NUREG-1320, U.S. Nuclear Regulatory Commission - Office of Nuclear Material Safety and Safeguard, Washington, DC.
- Mishima, J., 1994, *DOE HANDBOOK - Airborne Release Fractions/Rates and Respirable Fractions for Non Reactor Nuclear Facilities*, DOE-HDBK-3010-94, U.S. Department of Energy, Washington, D.C.
- Selby, D. H., 1968, *Meteorology and Atomic Energy - 1968*, U.S. Atomic Energy Commission, Washington, D.C.
- Sutter, S. L., 1982, *Accident Generalized Particulate Materials and Their Characteristics - A Review of Background Information*, NUREG/CR-2651, U.S. Nuclear Regulatory Commission, Washington, D.C.

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APPENDIX A

FORCES THAT SEPARATE AND SUSPEND MATERIALS

A. Types of Forces that Separate and Suspend Materials in the Gaseous State.

1. All over pressure vented upon loss of containment or confinement.
2. Material Volatilized by Initiating Event. Fraction of material-of-concern volatilized (depending on the conditions) resulting in conversion of material to the gaseous state. All overpressure is vented upon loss of containment/confinement, and all material in gaseous state may be eventually released. Material made airborne can be affected by subsequent chemical and physical environment (e.g., condensation, reaction with airborne materials or material encountered, and chemical reaction to produce particulate materials).

B. Types of Forces that Separate and Suspend Solid and Liquids

B.1 Materials

Materials in these physical states must be separated, suspended, and transported to the local flow field to become an inhalation hazard to the downwind population. The following is a list of solids:

- Elastic-plastic solids such as metals
- Brittle solids such as glass or aggregate
- Powders with various physical characteristics
 - homogenous beds of the same or similar particles with a depth greater than two particle diameters thick
 - heterogenous beds (sparse deposits of particles covering the surface of a dissimilar material such as dust on a hard surface).

Each type of solid is most readily subdivided by different types of forces/stresses. Elastic-plastic materials must be stretched beyond their tensile strength or, for reactive metal, oxidized into another compound that forms particles. Brittle solids are most readily fragmented by crush-impact forces that exceed the tensile strength of the material. Force in necessary

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at the particle-to-particle interface to separate an individual particle or a cluster of particles. Suspension of surface contamination requires the separation of the contaminant from the bulk material or the suspension of the bulk material (the types of forces/stresses that fragment and suspend solids was covered previously).

In most cases involving liquids, the material-of-concern is the solute or particulate materials suspended in a liquid. Materials-of-concern are associated with both aqueous and organic liquids. In these cases, suspension of the material-of-concern involves subdivision of the bulk liquid (formation of droplets) and not the evaporation of the solvent.

B.2 Initiating Events

The following are major initiating events that may generate the forces/stresses mentioned above:

- Explosion/Energetic Events: Fast energy releasing phenomena with chemical or physical sources of energy. If the energy release is in microseconds (detonation, if the energy source is chemical, the flame speeds at or exceeding sonic velocities for combustion processed), the event results in shock wave and pressure impulse effects. The overpressure can be 20 times the initial pressure. If the energy release is in milliseconds to second (deflagrations, if the energy source is chemical, the flame speed is subsonic; a typical laminar flame speed for a hydrocarbon systems is 0.3 m/s), the products may be pressure and possible heat.
- Venting: Venting of pressurized volumes is the physical analog of a deflagration without heat (although heat may be the cause of the pressurization). Powders and liquids in the pressurized volume before and during venting can be swept by the flow induced by the venting. If the pressurization is long enough to pressurize the entire volume, the powders are separated by the expansion of the gas between powder particles, and the liquids can be swept along with the flow by the negative pressure induced by the rapid release of the gases. If pressurization is rapid and the entire volume is not adequately pressurized, the airborne release is generally less than for full pressurization.
- Fire: Fires can be a homogeneous or heterogeneous phenomenon. Homogenous systems are those that involve both the fuel and oxidant (typically air) in the gaseous phase. Heterogeneous systems involve the generation of the fuel in the vapor state (evaporation of a combustible liquid or pyrolysis of a combustible solid). The products of importance to the airborne release process are heat and gas flow (both the upward flow of vapors and the convective flow of the air).

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- **Crush-Impact:** Imposes force upon the surface of the material impacted and can fragment both solids (e.g., brittle fracture, displacement of powders) and liquids (e.g., splashing and droplet formation by displacement and shear). If the surface is not fragmented, particles lying on the surface (e.g., surface contamination, corrosion products) can be jarred from the surface and suspended by vibratory/shock effects.
- **Free-Fall Spill:** Shear stress at the air-material interface can shed particles/droplets during the fall. Air resistance can result in the disruption of the face of the falling slug of powder and particles can be shed into the area of lower pressure resulting from the restoration of the streamlines on the back face of the slug. Impact can induce breakup of solids, powder slugs and liquids.
- **Aerodynamic Entrainment:** Air passing over a surface or directed onto a surface can induce flow and turbulence that can suspend particles on or composing the surface impacted. Obstruction to the air flow around or over the surface can result in suspension of materials from the surface.

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APPENDIX B**MODELS AND VALUES TO BE USED IN ACCIDENT ANALYSIS**

Specific models and values to be used in the accident analysis are not yet approved. See section 6.2.1 of this procedure.

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APPENDIX C

ITEMS TO BE CONSIDERED IN ACCIDENT ANALYSIS

Consider the following when calculating release quantities:

- Cesium can be volatilized in fire or high heat scenarios.
- The value of 10 micrometers as the diameter of a particle that is respirable is based on a density of 1g/cm^3 . The diameter of a respirable particle for more dense materials is smaller.
- Credit can be taken for plume depletion with use of the Chamberlin model (Selby 1968, Section 5-3.2).
- Liquid droplets larger than 10 micrometers may evaporate while traveling downwind. The extent of evaporation might be such that the droplet diameter is within the size range considered respirable.

APPENDIX C. PROCEDURE TO FOLLOW FOR CALCULATING RELEASE CONSEQUENCES

(Work Procedure WP-5.14, "Calculation of Airborne Release Consequences for Radioactive and Toxic Materials," excerpted from the former WHC manual WHC-CM-6-32, *Safety Analysis and Nuclear Engineering Work Procedures*.)

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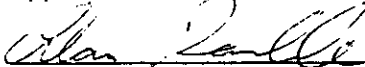
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Safety Analysis and
Nuclear EngineeringCALCULATION OF AIRBORNE RELEASE
CONSEQUENCES FOR RADIOACTIVE AND
TOXIC MATERIALS

Approved by

A. L. Ramble, Manager
Safety Analysis and Nuclear
Engineering

1.0 INTRODUCTION

The purpose of this procedure is to describe the methods used to evaluate the consequences of accidental releases of radioactive or toxic materials.

2.0 SCOPE

The evaluation of accident scenarios for safety analysis reports can require evaluation of the consequences of airborne releases of radioactive or toxic materials. This procedure describes the methods to be used for evaluating the consequences of these releases, and includes atmospheric dispersion models and the evaluation of the health effects. Evaluation of the scenarios and release fractions are covered by other procedures.

Release consequence evaluations require the analyst to be familiar with atmospheric dispersion models and radiological and/or toxic health effects determinations. Therefore, this procedure must be supplemented with detailed study of the models in order for the calculations to be performed successfully.

3.0 DEFINITIONS

Hanford Environmental Dose Overview Panel (HEDOP). An inter-contractor panel formed by DOE-RL to ensure that dose calculations are performed uniformly at the Hanford Site.

HEDOP Reviewer. Person designated by the HEDOP panel to perform HEDOP reviews.

Emergency Response Planning Guideline (ERPG-1). The maximum airborne concentration to which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing other than mild transient adverse health effects or perceiving a clearly defined objectionable odor.

ERPG-2. The maximum airborne concentration to which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action.

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ERPG-3. The maximum airborne concentration to which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects.

Permissible Exposure Limit - Time Weighted Average (PEL-TWA). An employee's average airborne exposure in any 8-hour work shift of a 40-hour work week that shall not be exceeded.

4.0 RESPONSIBILITIES

The analyst performs dispersion calculations.

A technical peer reviewer ensures the technical adequacy of the calculations.

A HEDOP reviewer ensures that the calculations are performed in a manner that is consistent with the HEDOP policies and procedures. The HEDOP and technical peer reviews may be performed by the same individual.

First line supervision ensures that the requirement of this procedure is carried out before approval of the transmittal of the analysis. First line supervision also ensures that the analysis and peer reviews are performed by technically competent analysts.

The customer provides the following information to the analyst before the analysis begins:

- Inventory released, including specific isotopes or toxic material
- Location of release
- Type of release (ground level, stack etc.)
- Adequate details of the release scenario to determine if models such as building wake or plume meander are appropriate.

This information should be in writing. If the information is not from an approved, easily retrieved document, the information is included in the analysis documentation as submitted by the customer.

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Safety Analysis and
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Consequences are calculated at the maximum onsite and offsite receptor locations. The definitions given in WHC-CM-4-46 (WHC, 1994) is normally used for these receptors unless another documented definition is provided by the customer. If other locations are requested, this is documented in the report.

The maximum onsite location is determined by evaluating the dispersion factor at each of 16 sectors around the release point and choosing the location with the highest dispersion factor. The site boundary for these calculations is the near bank of the Columbia river on the north and the east.

5.2. ATMOSPHERIC DISPERSION

The consequences to the receptor depends on the dispersion that occurs between the release point and the receptor. Atmospheric dispersion is usually calculated using a Gaussian plume model based on Hanford meteorology data. The Hanford Site has an extensive onsite meteorological monitoring program; therefore, atmospheric dispersion coefficients based on these data can be used to evaluate release consequences. These data are displayed in joint frequency tables. The model used for atmospheric dispersion is based on use of the following:

- Gaussian plume model
- Hanford Meteorology
- Interpolation methods specified by Nuclear Regulatory Commission (NRC) Regulatory Guide 1.145. (NRC 1982)

Since atmospheric conditions fluctuate, a bounding atmospheric condition is determined to be that condition which causes a downwind concentration of airborne contaminants that is exceeded only for a small fraction of time due to weather fluctuations. NRC 1982 defines this fraction of exceedance as 0.5% for each sector or 5% for the overall Site. (The Hanford Site is divided into 16 sectors, which represent 16 compass directions.)

Integrated atmospheric dispersion coefficient (χ/Q') values are generated for weather conditions that result in downwind concentrations which are exceeded only 0.5% of the time in the maximum sector, or 5% of the time for the overall site. (The GXQ computer code is the preferred method for calculating the atmospheric dispersion coefficients [Hey 1993a and Hey 1993b]).

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These χ/Q' values are also referred to as 99.5% maximum sector and 95% overall Site χ/Q' values, respectively. The greater of these two values is called the bounding χ/Q' value, and is used to assess the dose consequences in the accident scenarios. These bounding χ/Q' values represent minimum dispersing conditions that result in maximum downwind concentrations (concentrations exceeded only a very small fraction of the time). These χ/Q' values will, therefore, result in very conservative estimates of accident consequences.

The 99.5%/95% conditions described above are typical conditions for calculations for Safety Analysis Reports (SAR), but different assumptions may be appropriate for different types of calculations. Customers may specify 50% or annual average meteorology, or may specify a certain windspeed and stability class. The assumption of 50% meteorology is typically used for beyond design basis events or environmental studies. Calculations using different models, such as terrain specific models, may be required for some accidents. These variations are acceptable but the analyst must demonstrate and the peer/HEDOP reviewer must concur, that the use of the models is appropriate for the cases involved.

5.3 POTENTIAL ATMOSPHERIC DISPERSION CORRECTION MODELS

There are a number of effects that can reduce the dose to the receptor, several of which are discussed below. Models, however, must be used with care because specific models are only appropriate for certain scenarios. The analyst needs to understand the models and be certain that the one used is appropriate before including it in the calculation. The following descriptions are not intended to replace detailed references that the analyst uses for a complete understanding of the models.

The following are models that can be applied to atmospheric dispersion calculations. It is not intended that this list be totally comprehensive. Other models may be applied to specific scenarios; however, use of models must be justified, and reviewed thoroughly by peer and HEDOP reviewers.

5.3.1 Plume Meander

Plume meander takes into account that, for releases that occur over extended period of time, the plume will change directions. The effect is reduced concentration of radionuclides. NRC 1982 model or the "Fifth Power Law" correction may be applied. Plume meander should not be used for toxic release calculations because toxic limits are normally based on peak concentration limits. Plume meander should not be applied if the release rates vary significantly. The NRC 1982 guide model assumes a minimum release time of approximately 1 hour.

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5.3.2 Building Wake

The radionuclide concentrations to the onsite receptor can be substantially decreased by building wake (turbulence created by a structure that is at or near the release point). The GENII model, the MAACS virtual source model, or the NRC 1982 model may be used for building wake calculations.

The building wake model should not be used for accidents that may involve the collapse of the building, such as an earthquake affecting a non-seismically qualified building. The smallest cross sectional area is normally used to determine the building wake correction.

5.3.3 Plume Rise

Plume rise from momentum or thermal effects may result in decreased radionuclide concentrations. This type of model can be used if the scenario contains specific information on temperature and/or momentum effects. However, if the plume rise model is used, the effects of stack downwash, plume trapping and ground effects need to be considered.

5.3.4 Stack Release

Stack releases generally result in significantly reduced onsite dose consequences. This occurs because the plume must travel some distance (usually a few hundred meters) away from the release point before it "touches down" to impact a ground level receptor. The farther the plume travels, the more atmospheric dilution takes place. NRC 1982 allows credit for an elevated release when the release point is at least 2-1/2 times the height of adjacent solid structures. This criteria is established to ensure that a building wake does not cause the elevated release to be driven back to the ground.

The location of the maximum onsite receptor needs to be calculated for an elevated (stack) release by calculating doses at different distances to determine the maximum. This maximum corresponds to the point at which the plume centerline hits the ground, and may be farther away than the maximum receptor for a ground level release.

6.0 RADIOLOGICAL DOSE CALCULATIONS

6.1 RADIOLOGICAL EXPOSURE PATHWAYS

There are two potential radiological exposure pathways associated with accidental releases of radioactive materials: the internal and external exposure pathways. The total radiological dose received by an individual is.

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equal to the sum of the dose contributions from the internal and external exposure pathways.

The major internal exposure pathway for Hanford releases is the inhalation pathway. Exposure through the inhalation pathway occurs when an accident results in a release of airborne radioactive materials that is transported downwind and inhaled or when radioactive material particles are resuspended. A resuspension dose is usually much smaller than a dose from direct inhalation of released particles, but may need to be considered for specific scenarios.

The other potential internal exposure pathway is the ingestion pathway. Exposure through the ingestion pathway occurs when radioactive materials that have been deposited offsite are ingested, either by eating crops grown in, or animals raised on, contaminated soil, or through drinking contaminated water. Potential doses from the ingestion pathway are not included in the comparison to risk guidelines because there are existing U.S. Department of Energy (DOE), DOE-RL, state, and federal programs to prevent ingestion of contaminated food in the event of an accident. The primary determinant of exposure from the ingestion pathway is the effectiveness of public health measures (i.e., interdiction) rather than the severity of the accident itself. The ingestion pathway, if it occurs, is a slow-to-develop pathway and is not considered an immediate threat to an exposed population in the same sense as airborne plume exposures. Therefore, the ingestion pathway is not usually included in the calculation of the radiological dose for comparison against the risk acceptance criteria.

The potential external exposure pathways include submersion, ground shine, and direct exposure from a concentrated radioactive source. Submersion refers to the external dose received by a person located in the airborne radioactive plume during plume passage. Ground shine refers to the external dose received by a person standing on ground contaminated by radioactive materials deposited during passage of the airborne radioactive plume.

For the radionuclide mixes normally involved in Hanford analyses, the submersion doses are 3 to 4 orders of magnitude lower than the inhalation doses. This, however, may not be true for doses resulting from criticalities or releases from an operating reactor. In analyzing these accident scenarios, submersion doses may need to be examined more carefully.

For scenarios involving the formation of a pool of radioactive liquid, the direct dose contribution to the total dose may be significant, and therefore should be included in the calculation of the total radiological dose used for comparison to the risk acceptance guidelines.

Scenarios involving prevention of ingestion dose by interdiction of food may require estimates of ingestion during the period required to implement interdiction procedures. These doses will normally be small but may have to

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be considered for some scenarios. Also, scenarios that assume respirable fractions of less than 1 should consider effects of the dose from ingestion due to swallowing inhaled particles that are too large to be respirable.

6.2 DOSE CALCULATION METHODOLOGY

The effects of radioactive release can be summarized as dose or Total effective dose equivalent (TEDE). The methods described in ICRP Publications 26 and 30 are used for the calculations. Worst case solubility factors should be assumed unless the accident scenario indicates that other factors are appropriate. The inhalation dose can be computed by the GENII code. Alternately a hand calculation can be made of the doses using the following formula:

$$D \text{ (Sv)} = Q \text{ (L)} \times \frac{X}{Q'} \text{ (s/m}^3\text{)} \times R \text{ (m}^3\text{/s)} \times \text{ULD (Sv/L)}$$

where

- Q = respirable material released
- X/Q' = Integrated atmospheric dispersion coefficient
- R = Breathing rate
 - = $3.3 \times 10^{-4} \text{ m}^3\text{/s}$ typical breathing rate (light activity)
 - = $2.7 \times 10^{-4} \text{ m}^3\text{/s}$ typical breathing rate (24 hr average)
- ULD = dose per unit inhaled

The typical acute breathing rate ($3.3 \times 10^{-4} \text{ m}^3\text{/s}$) is used to calculate the onsite receptor dose for all release durations up to one week. The chronic breathing rate ($2.7 \times 10^{-4} \text{ m}^3\text{/s}$) is used for onsite receptor dose calculations for release durations greater than one week. Doses are normally reported in Sieverts but rems may be used if the customer requests these units.

The ULD defined above is calculated by multiplying the amount of each isotope in a unit volume times the dose conversion factor.

If ingestion doses, groundshine, and resuspension dose calculations are necessary the GENII code is used. These models do not lend themselves to hand calculations; however, it may be possible to demonstrate that the contribution from these mechanisms is not significant.

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7.0 TOXIC MATERIAL RELEASE CONSEQUENCES

The toxic chemical exposure effects are evaluated for comparison against the safety analysis risk acceptance guidelines from WHC, 1994. This evaluation requires an estimate of the toxic chemical concentrations at the maximum onsite and offsite individual locations as a result of releases.

Evaluation of the effects of chemical exposure has been conducted only for the airborne pathway. Exposure limits are based on the inhalation pathway. Exposure to skin and the eyes is considered in the development of the limits for corrosives and irritants, but inhalation is the dominant pathway.

It is conservative to assume 100% of the particles transported to the maximum onsite/offsite individual are respirable. It can be nonconservative to consider only the fraction of particles in the respirable range since larger particles can cause skin or eye irritation. It is appropriate to reduce the chemical concentration at the maximum onsite/offsite individual by a respirable fraction only if it can be demonstrated that the chemicals involved have a health effect if inhaled.

Concentrations at the maximum onsite/offsite individual are computed using the Gaussian plume model described in Section 5.2 of this procedure for particles and gases. All material reaching the lung is assumed to be retained in the body.

The other potential internal exposure pathway is the ingestion pathway. Ingestion of chemicals could occur from consuming crops or animals that have been exposed to the chemicals. Potential chemical exposures from the ingestion pathway are not normally included because there are federal and state programs to prevent ingestion of contaminated food.

In evaluating the consequences of accidental releases involving multiple chemicals, the chemicals should be divided into three categories:

- Total particulates
- Corrosives and irritants
- Toxic chemicals.

Total particulates are considered because even though the individual constituents may not be toxic, high air concentrations of particulates can interfere with breathing. Both liquid droplets and solid particles are considered particulates. Corrosives and irritants are chemicals that can cause damage to organs such as the eyes, skin, or lungs, and usually exhibit a rapid effect. Toxic chemicals are chemicals that can affect vital organs. The risk acceptance guidelines were based on Emergency Response Planning Guidelines using the techniques developed by the Management and Operations (M&O) Committee (Craig 1995a).

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For a continuous release of toxic materials, the peak concentration can be calculated using the following equation:

$$C \text{ (mg/m}^3\text{)} = Q' \text{ (mg/s)} \times \frac{X}{Q'} \text{ (s/m}^3\text{)} \quad (2)$$

where:

C = Peak concentration
 Q' = Toxic material release rate
 X/Q' = Continuous release atmospheric dispersion coefficient.

The M&O criteria (Craig 1995a) contain the chemical concentration guidelines used to evaluate the acceptability of the risk of the releases from a toxicological health effects point of view. The risk acceptance guidelines are given in terms of ERPG and PEL-TWA values for the maximum onsite and offsite individuals as a function of the accident frequency. These criteria are also given in WHC 1994.

For the release of a single chemical, the concentration at the receptor point can be determined using Equation 2, and compared to the risk guidelines. For releases involving several different chemical releases, a sum of fraction approach can be taken, in which chemicals with similar health effects can be grouped together. See WHC-SD-WM-SARR-011 (Van Keuren 1995) for an example of this approach.

Exposure time is determined based on the following guidance taken from Craig 1995a "Exposure time: In practice, observed atmospheric concentrations of chemicals downwind of a source vary widely about the mean concentration measured over a period of time. Unless information to the contrary is available, published limit parameters or guidelines must be treated as ceiling values at the point of interest. For practical purposes, the peak 15 minute average concentration is treated as the instantaneous concentration. It is recommended that this concentration value be used for comparison with the primary concentration guidelines."

For chemicals that are known to have dose-dependent health effects rather than concentration-dependent effects, a 1 hour average may be used. However if the chemicals are not all known to be dose-dependent, the 15 minute average should be used for releases of 15 minutes to 1 hour. Tank waste, for instance, contains a mixture of dose-dependent and concentration-dependent chemicals. A peak 15-minute average should be used for the tank waste evaluations

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Averaging over 15 minutes for releases that produces a very short exposure time (such as a puff release), is potentially nonconservative because of chemicals that have ceiling limits, i.e. (concentrations that should not be exceeded). There is some recent guidance from Craig 1995b that states "For practical reasons (e.g., limitations of instantaneous concentration monitoring for many chemicals) the peak 15-minute average value at the receptor point of interest is used except for those substances that may cause immediate irritation when exposure is short (e.g., hydrogen sulfide, sulfur dioxide). In such cases if the release scenario gives rise to peak concentrations significantly higher than the peak 15-minute average concentration, then a shorter averaging time (not less than 1 minute) should be used." The chemicals involved in a release should be examined to determine if the chemicals involved cause immediate irritation. The chemicals should be assumed to cause immediate irritation unless it can be demonstrated otherwise.

A very short duration release (puff release) of chemicals including corrosives and irritants can be modelled conservatively as a 1 minute continuous release.

The ERPGs are by definition based on a maximum of a 1-hour exposure. Exposures over 1 hour should not be compared to ERPG limits without evaluating the chemicals involved by a toxicologist. It should, however, be considered that most of the chemicals of concern at Hanford will cause almost immediate irritation; therefore, it is unlikely that a receptor will remain in a plume for more than 1 hour, even if the accident scenario release duration is longer.

Craig 1995a should be consulted for more details on these issues.

8.0 REVIEWS/DOCUMENTATION

Both technical peer, and HEDOP reviews are required for these analyses. The reviews are described in WHC-CM-6-32, Section 6.2.

Documentation of the analyses must be performed per the procedure on calculation notes. The requirements are described in WHC-CM-6-32, Section 6.7.

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APPENDIX D. PROCEDURE TO FOLLOW FOR TECHNICAL PEER REVIEWS AND HEDOP REVIEWS

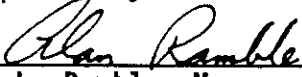
(Work Procedure WP-6.2, "Technical Peer Reviews and Hanford Environmental Dose Overview Panel Reviews," excerpted from the former WHC manual WHC-CM-6-32, *Safety Analysis and Nuclear Engineering Work Procedures*.)

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Approved by


A. L. Ramble, Manager
Safety Analysis and Nuclear
Engineering

1.0 PURPOSE

The purpose of this procedure is to provide the requirements for performing and documenting technical peer reviews and Hanford Environmental Dose Overview Panel (HEDOP) reviews of analyses.

2.0 SCOPE

This procedure applies to analyses performed in support of safety analyses, equipment safety classifications, hazard categorizations, environmental assessments, criticality analyses, determinations of technical or operational safety requirements, potential damage assessments, or any similar types of analyses, including analyses that scale results from previous analyses.

3.0 DEFINITIONS

Technical Peer Review. A detailed review of an analysis to verify that it is appropriate, technically correct in all respects, properly documented, and that it satisfies applicable requirements as to content and format, and is properly documented. This type of review must be carried out by an analyst or team of analysts who are qualified to perform the analysis being reviewed, but who have not contributed substantially to the analysis.

Hanford Environmental Dose Overview Panel (HEDOP) Review. A review by a panel-approved HEDOP reviewer (who has not contributed substantially to the analysis) to ensure that appropriate and consistent methods are used for environmental and dose assessments at the Hanford Site. This review is generally applicable to any analysis involving a potential or actual environmental release and transport of potentially harmful material at the Hanford Site. A technical peer review and HEDOP review may be performed by the same person if he/she is qualified to do both reviews.

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4.0 RESPONSIBILITIES

The analyst (lead analyst or coordinator, if the work was done by more than one analyst) arranges and documents technical peer reviews and HEDOP reviews (if required) of analyses. If the analysis is performed by another organization or contractor for the requesting organization, the person directly coordinating the analysis arranges and documents the required reviews. If more than one technical peer reviewer is involved in the review of a document, the analyst or analysis coordinator designates a lead reviewer to coordinate the review. The analyst (or lead analyst or coordinator) ensures that the entire review package (including HEDOP review, if required) is made a permanent part of the analysis document.

The technical peer reviewer conducts the review in accordance with this procedure and provides the required documentation of the review to the analyst. If more than one technical peer reviewer is involved in the document review, the analyst designates a lead reviewer who is responsible for coordinating the review, and ensuring that all parts of the document are covered by the review. Each reviewer ensures that all sections of the document that may affect his or her assigned section have been reviewed and corrected with no gaps in coverage.

First line supervision ensures that the requirements of this procedure are met before approving transmittal of the analysis document to the customer.

5.0 REQUIREMENTS

This section provides the requirements that must be followed in conducting and documenting a technical peer review and HEDOP review (if required).

5.1 GENERAL CONDUCT

In order to conduct an effective review, the technical reviewer should have the competence and expertise necessary to have performed the analysis being reviewed, but should not have contributed substantially to the analysis.

5.2 REVIEW CHRONOLOGY

In some cases, a reviewer competent in all areas of the analysis will not be available, especially if the work was done by more than one analyst. A series of reviewers will then be required to look at the various parts of the analysis. Because actions of a reviewer may affect later sections of the analysis, the reviews should normally be done in series, rather than in parallel, with comments by each reviewer being fully resolved before the next

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section is submitted to the next reviewer. Each reviewer should ensure that all sections of the document that may affect his or her assigned section have already been reviewed and corrected with no gaps in coverage. After the review is complete, the lead reviewer checks to ensure that the entire document has been covered with no gaps.

In exceptional cases, the review can be done in parallel, however this will be much more expensive in terms of total effort, and can easily lead to defects. Parallel review requires very close coordination among the reviewers and the analyst.

5.3 STATEMENT OF PROBLEM

Every analysis should have a problem statement detailing the objectives of the analysis and defining any specified information or assumptions to be used. As a minimum, the following should be considered:

- a. The location of the subject facility, process, or event should be specified. In cases where the location is not defined (e.g. transportation accidents), available information and any requirements applying to this aspect of the problem should be given.
- b. Physical arrangements and design details important to the analysis should be completely described.
- c. If this is a radiological or toxicological release analysis, is the source term formulation part of the problem, or is the source term being supplied by the customer? This should be clearly stated in the document.
- d. Any customer-specified assumptions or requirements that have a bearing on the problem formulation, such as accident scenarios, specified receptor locations, dispersion conditions, etc., should be spelled out in detail and labeled as customer-specified.
- e. The required end products of the analysis should be carefully defined.

Note that the problem definition is not necessarily all physically located at the beginning of the document, but may be logically divided among various sections as appropriate.

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5.4 ASSUMPTIONS

Assumptions specifically formulated for use in the analysis should be explicitly stated, and applicable supporting data or information well documented. If an assumption resulted from engineering judgment, or was an educated guess, this should be clearly stated in the analysis document.

The reviewer must estimate the degree of uncertainty based on judgment and on how well the assumption is supported and determine whether enough safety factor has been applied to cover the uncertainty. In particular, the reviewer must carefully determine whether any of the conclusions of the analysis could be impacted by the degree of collective uncertainty in the assumptions.

5.5 REPRODUCIBILITY

The technical peer reviewer should insist that every number and piece of information used to produce a hand calculation or used as input for a computer code be explicitly stated in the document, or in an attachment that will stay with the document. All data and other information that serves as input to the calculation should be referenced. References that may not be retrievable in the future, particularly informal internal memos which contain critical supporting information, should be added to the document as attachments. If the analysis is properly documented, the reviewer should be able to completely reproduce all calculations, including all the code input files, using only the information supplied in the document.

The analyst should be able to supply the reviewer with a copy of any document cited in the analysis.

5.6 MATHEMATICAL MODELS AND CORRELATIONS

If a formulation is from a published reference the main concern is whether the material has been correctly used by the analyst. As a minimum, the reviewer should check the analyst's formulation against the original source, and check whether the analyst is operating within the range of validity of the model, or within the range of data used for the correlation. If the analyst has used the model or correlation outside its advertised range, this should be clearly stated and justified in the document.

If this type of material has been taken from an unpublished reference (such as an internal memo) or was developed by the analyst, the reviewer should regard it as unproven, and must carefully examine the source document or the analyst's development to judge the quality of the model or correlation. The reviewer should be satisfied that the uncertainties thus introduced will not impact the conclusions of the document.

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As a final check in all cases, the reviewer should carefully examine the resulting formulations for dimensional consistency. Any algebraic error will usually show up as a dimensional inconsistency in the result. Unless they are dimensionless, all numerical constants in a formula (and throughout the analysis) should be supplied with units.

5.7 HAND CALCULATIONS

A basic requirement for any analysis document is the presence of all information necessary to reconstruct the analysis, including hand calculations. The reviewer should normally duplicate all the hand calculations, including unit conversions, formula evaluations, etc. using the information provided in the document. If information (other than standard conversion factors, etc.) is missing, the document should be returned to the analyst for correction before the calculations themselves are checked. If the hand calculations are of a complex nature, sample calculations included in or attached to, the document can be highly useful, and should be requested by the reviewer if deemed appropriate.

5.8 SPREADSHEETS

A spreadsheet-type calculator (including MATHCAD) is never to be depended on to yield correct results in any particular instance, and results must be independently verified each time it is used. Calculations using such software should be reported exactly as hand calculations would be. The following criteria apply:

- a. A spreadsheet cannot be cited in the analysis report, and should be completely transparent to the reader.
- b. The calculations performed using a spreadsheet should be completely described so that the results can be verified by the reader using only information in the report.
- c. The spreadsheet should be made available to the reviewer for checking, but the results should be reviewed as hand calculations.

5.9 ACCURACY

Results should not claim greater accuracy than is merited. Although some calculations demand much higher precision (e.g., calculations of k_{eff} in criticality analyses), as a general rule, two significant figures in the final results, with three being carried in the intermediate steps (to avoid excessive roundoff errors), will usually be reasonable and appropriate.

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5.10 COMPUTER CODES

All computer codes used in the analysis must meet at least one of the following requirements:

- a. The computer code is under the configuration control program described in WHC-CM-6-32, *Safety Analysis and Nuclear Engineering Work Procedures*, WP-4.3, "Software Configuration Control."
- b. The computer code is commercial software (generally available to the public) and sample calculations are performed to verify the code output.
- c. The computer code source listing is provided in the document and sample calculations are performed to verify the code output. The name and version of the compiler and the type of computer used should also be provided in the analysis document.

Codes should be completely documented with regard to version numbers, release dates and references to users' manuals. In addition, all data files used, with associated release numbers or dates, should be listed. A set of typical input files should be attached to the analysis document for all the types of cases run. The objective is to have enough information in the report to allow a complete reconstruction of all the input cases and to actually run the code at some later date.

Input and output files for all cases run should be supplied by the analyst to the reviewer in whatever form is mutually convenient. The reviewer should then check all entries in the input files to verify that they are consistent with the corresponding information in the document, and that the code has been run correctly in every case. Input parameter lists in the output files should be checked against the input files. Results in the output files should then be carefully checked against the corresponding information presented in the document.

5.11 CONCLUSION

The conclusion should be checked to ensure that it addresses all required objectives in the problem statement. All results given in the conclusion should be carefully checked to ensure consistency with the results of the analysis, and with all other information given in the document. If the results are being evaluated against limits or other criteria, the limits or criteria should be well documented. Since the validity of the conclusions will be directly affected, the reviewer must carefully check such limits or criteria against the original sources to ensure that they are correct and appropriate.

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CHECKLIST FOR PEER REVIEW

Document Reviewed:

Scope of Review:

Yes	No	NA	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	* Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Problem completely defined.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Accident scenarios developed in a clear and logical manner.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Necessary assumptions explicitly stated and supported.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Computer codes and data files documented.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Data used in calculations explicitly stated in document.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Data checked for consistency with original source information as applicable.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Mathematical derivations checked including dimensional consistency of results.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Models appropriate and used within range of validity or use outside range of established validity justified.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Hand calculations checked for errors. Spreadsheet results should be treated exactly the same as hand calculations.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Software input correct and consistent with document reviewed.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Software output consistent with input and with results reported in document reviewed.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Limits/criteria/guidelines applied to analysis results are appropriate and referenced. Limits/criteria/guidelines checked against references.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Safety margins consistent with good engineering practices.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Conclusions consistent with analytical results and applicable limits.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Results and conclusions address all points required in the problem statement.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Format consistent with appropriate NRC Regulatory Guide or other standards
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	* Review calculations, comments, and/or notes are attached.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Document approved.

Reviewer (Printed Name and Signature)

Date

* Any calculations, comments, or notes generated as part of this review should be signed, dated and attached to this checklist. Such material should be labeled and recorded in such a manner as to be intelligible to a technically qualified third party.

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If the results are being evaluated against limits (such as radiological risk guidelines), margins should be evaluated relative to the degree of uncertainty in the analysis. For example, if the results are several orders of magnitude below the limits, the conclusions can usually be considered secure. If, however, the results are at, or close to the limits, the uncertainties and degree of conservatism in the analysis become much more critical and should be examined with care. In this case the document should discuss and justify the validity of the conclusions in terms of the conservatism of the analysis.

6.0 HEDOP REVIEWS

The HEDOP reviews are conducted and documented according to requirements contained in Chapter 4 of the current HEDOP Policy Manual. This review is generally required for any analysis involving a potential or actual environmental release and for the transport of potentially harmful material at the Hanford Site. In cases where exposures are scaled from unit release results developed in a previous analysis that has undergone a HEDOP review, a new HEDOP review is not usually required. In all other cases (e.g., a change in X/Q or a change in the character of the release other than just the amount) a new HEDOP review, as well as a technical peer review are required.

The technical peer review must be completed and documented before the HEDOP review can begin.

7.0 DOCUMENTATION

As a minimum, the technical peer review shall be documented using a checklist equivalent to the one attached as Appendix A to this procedure. The review documentation shall clearly specify which parts of the analysis document were covered by the review. Additional commentary, notes, calculations, etc. may be attached to the checklist as deemed appropriate by the reviewer. Each page added in the review documentation shall be numbered, signed and dated by the reviewer. The documentation of the technical peer review (and the documentation of the HEDOP review, if required) shall be made a permanent part of the analysis document.

If more than one technical peer reviewer is involved, each reviewer shall completely document his/her review of the assigned section of the analysis document. The lead reviewer (or document coordinator) shall then assemble the collected reviews and check to ensure that all parts of the analysis document that were intended to be covered by the review have been covered. The lead reviewer's (or document coordinator's) approval signature on the Engineering Data Transmittal cover sheet certifies that this check has been made.

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